McGILL UNIVERSITY

PAPERS FROM THE DEPARTMENT

OF

GEOLOGY.

No. 21.—The Artesian and other Deep Wells on the Island of Montreal

BY

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AND

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[Reprinted from the Annual Report of the Geological Survey of Canada, Part O., Vol xiv.]

Montreal, 1906.

GEOLOGICAL SURVEY OF CANADA
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THE ARTESIAN AND OTHER DEEP WELLS

ON THE

ISLAND OF MONTREAL

BY

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OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST
EXCELLENT MAJESTY
1904

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No. 863.

The Artesian and other deep Wells on the Island of Montreal.

I. Introduction.

II. Some General Facts concerning Artesian Wells.

III. Sketch of the Geology of the vicinity of Montreal (with geological map of the district).

IV. List and Description of the Wells which have been sunk on the Island.

V. Chemical Composition of the Waters obtained by boring.

VI. General Conclusions.

THE ARTESIAN AND OTHER DEEP WELLS

ON THE

ISLAND OF MONTREAL

INTRODUCTION

During the past fifteen years a large number of borings have been put down along the eastern side of the Island of Montreal, for the purpose of obtaining water. Most of these have been located in the city of Montreal while some of them are situated in the suburban districts, and in most instances large supplies of good water have been obtained. In other cases, however, the water obtained was saline in character, while in still other cases, little or no water of any kind was found.

This source of water supply in the district about Montreal bids fair to assume an ever increasing importance in the future; and it has therefore been deemed advisable to gather together all the facts which it is possible to secure concerning the borings which have already been made—more especially as much of this information if not now obtained and recorded will be permanently lost—and at the same time by a study of the geology of the district to ascertain what light may be thrown on the character and origin of the subterranean water supplies and the probability of obtaining water by further borings. Importance of artesian water.

It is also of great importance to ascertain, if possible, whether any definite water bearing horizon or horizons exist in the subjacent strata. If there be such water-bearing horizons, it is of the greatest importance to ascertain their depth below the surface in various parts of the area, since, knowing this, it would be possible to determine where and at what depth one could rely on obtaining water by boring. Work of this kind in many other districts, as is well known, has resulted in the discovery and development of water supplies of great extent and of inestimable value.

If, on the other hand, definite water-bearing horizons prove to be absent, much may be learned from the geological structure of the area with regard to the general probability of securing water by drilling.

Accordingly for some years past the Geological Department of McGill University has been collecting information and data bearing on the artesian water supply of the Island of Montreal. Nearly all the deep wells on the island have been visited and all data concerning them which it was possible to secure has been collected and tabulated.

Method boring.

The borings have been made with the ordinary percussion drill. No diamond drill holes have been put down and, consequently, no proper cores of rock have been obtained from the bore holes. In most instances no detailed logs of the borings have been kept and no samples of the material obtained from the wells have been preserved by the drillers.

Samples from a few of the wells however, have been secured and were of the greatest value in supplementing and extending the knowledge of the succession of the underlying strata obtained from a study of the surface geology of the district.

Number of wells bored prior to close of year 1903.

In this report the endeavour is made to present as complete a description as possible, of every boring which has been put down on the Island of Montreal up to the close of the year 1903. Eighty-nine holes are included in the list. It is believed that the list is complete, but it is possible, that notwithstanding the diligent inquiries which have been made, a few wells may have escaped notice. If such be the case, the authors will regard it as a favour if anyone knowing of such omissions will give information concerning them to the Geological Department of McGill University. The Department will also be very glad to have any information concerning new wells which may be bored in future.

The analyses of the waters which are presented, are in most cases incomplete and therefore not wholly satisfactory, having been made by different analysts and chiefly for the purpose of determining the general character of the water obtained or its suitability for use in steam boilers, &c. In making analyses of waters the amounts of the several bases and acids present are determined, but the way in which these are combined must be left to a certain extent to the judgment of the analyst. In the case of the analyses presented in this report a uniform plan has not always been followed by the various analysts in combining the substances found, and thus the analyses are not always readily comparable with one another. No attempt, however, has been made to recalculate them as in most cases the data for this are insufficient.

Hard and soft waters.

Waters are referred to as Hard or Soft according to whether they contain large or small amounts of lime and magnesia salts in solution.

These may exist either as carbonates held in solution by carbonic acid or as sulphates. In both cases the water is hard, that is, it requires much soap in order to make a lather, because an insoluble compound is formed by the union of the lime or magnesia with the fatty acid of the soap. But in the first instance the hardness is said to be Temporary because it is removed by boiling the water, when the carbonic acid holding the carbonate of lime in solution is driven off and the salt precipitated, whereas in the second case the hardness cannot be thus removed and it is accordingly termed Permanent Hardness.

In order to ascertain the amount of the hardness, a simple method was proposed by Dr. Clark, which consists in ascertaining how many measures of a standard soap solution are needed to form a lather with a gallon of water. The hardness of the water as determined by this method is expressed in degrees.

With a few exceptions, the borings referred to in the present report have been drilled by Mr. Wallace Bell of Montreal, and to this gentleman, as well as to his partner Mr. William Bell, we are indebted for much information concerning them. We are also indebted to the owners of the various wells who have in all cases readily supplied us with all the facts in their possession concerning their respective properties. To all these gentlemen, as well as to Dr. J. T. Donald of Montreal and to Mr. John R. Barlow, City Surveyor, we desire to convey our most sincere thanks, at the same time expressing the hope that the information collected and here set forth may be of service to them, as well as to others who may in future contemplate sinking for water in this district.

The publication of the work having been undertaken by the Geological Survey of Canada, it appears as a Report of this Department.

SOME GENERAL FACTS CONCERNING ARTESIAN WELLS.

Before considering the records of the Artesian wells on the Island of Montreal, it seems advisable to review some of the conditions by which the occurrence of underground waters are affected. While it is proposed here to treat of these conditions only in a brief and general way, the reader who wishes further information is referred to a more extended description by Prof. T. C. Chamberlain, entitled 'The Requisite and Qualifying Conditions of Artesian Wells',* and to a later report by Mr. N. H. Darton, on 'Artesian Well Prospects in the Atlantic Coastal Plain Region.' † Movements of underground waters.

*Fifth Annual Report of the U. S. Geological Survey, pp. 125-174 ; 1885.
†Bull. No. 128, U. S. Geological Survey ; 1896.

In former times, before geological investigations had led to a know- ledge of the character and structure of the earth's crust, many fan- tastic and amusing views were entertained concerning the movement of water beneath the surface of the earth. The origin of springs was an especially fruitful source of speculation, the general opinion being that great holes existed in the floor of the ocean, into which the sea water ran, which water after pursuing a devious path through under- ground channels, emerged at the surface of the land in the form of springs. The Maelstrom, off the coast of Norway, and other well known whirlpools were supposed to owe their origin to the rapid down- ward passage of great volumes of sea water into such holes or caverns. In this way it was supposed that the sea was prevented from over- flowing, notwithstanding the immense volumes of water which were continually poured into it by the thousand rivers flowing from the land, the part played by evaporation in the case of the ocean water not being as yet realized. Many ingenious hypotheses were also put forward to explain the supposed upward movement of the water from the ocean into the hills where it appeared as springs* and also to explain the fact that spring water was fresh while the waters of the ocean were very salt.

Curious views concerning these in former times.

Value of geological study.

With the rise of the science of geology, however, based on an increas- ing knowledge of the structure of the earth's crust, underground waters came to be recognized as having their source and origin in the rain which falls upon the surface of the earth, while their perplexing movements became so clearly understood that it was possible in many cases to predict where they existed and where they might be brought to the surface by properly placed borings.

It is now well known that the precipitation in the form of rain and snow which falls upon the earth's surface is disposed of in three ways:

1—A portion of it drains off the land, finding its way by brooks and streams into the rivers and thus to the sea.

2—A second portion rises in vapour and is returned to the heavens as mists and clouds.

Underground waters have their source in rainfall.

3—Still another portion sinks into the earth's crust and disappears from view.

* Compare Butler, "A Satire on the Royal Society"—

"What is't that makes all fountains still
Within the earth to run up hill,
But on the outside down again,
As though th'attempt had been in vain?"

The relative proportion of the precipitation which is disposed of in these three ways respectively, varies greatly with the character of the surface and the climatic conditions of the area on which the precipitation takes place, but it may be stated, speaking very generally, that in regions of temperate climate, about one third of the precipitation is disposed of in each of the three ways mentioned.

That portion of the rainfall which sinks into the earth's crust here alone claims our attention. This water passes down through porous strata or in cracks and fissures, thus giving rise to a system of subterranean water circulation, and finally comes to the surface again at some lower level in the form of springs, or passing out into the sea along the continental margins is lost in the waters of the ocean.

In some localities, it is possible by boring, to tap these underground water supplies, thus bringing water to the surface in the form of

Artesian wells are artificial springs

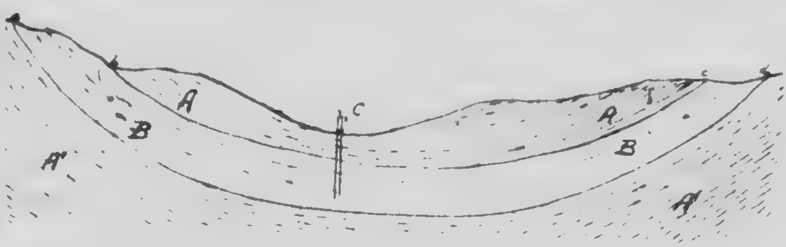

Figure 1. Showing a synclinal fold with a porous bed between two impervious ones.

Artesian wells, which may be regarded as artificial springs. One simple case of this is shown in the drawing presented in Figure 1. Here certain beds of differing composition are seen interstratified with one another. The beds A and A^1 are clays or shales, while the bed B is sand and gravel or their more compact equivalents sandstone and conglomerate. These rocks, originally laid down in horizontal beds, have been curved by pressure developed in the earth's crust, which curving has given to the area the form of a basin. The beds are tilted on either side at such an angle that they are exposed on the surface with the outcropping edge of B at a greater elevation than the surface of A. A and A^1 on account of their composition and texture, are practically impervious to water, and being in direct contact with the pervious or porous bed B, they act as confining beds which prevent the water which passes through B from escaping either upwards or downwards. These three beds present the features found in one class of channels through which underground water moves. The water enters the bed B at its outcrops ab and cd, and flows down the dip of the

stratum. If however, the bed B is tapped at a point C by a boring the water will rise to the approximate level of the ground water in I at ab and cd. The supply of water thus obtained will constitute ar artesian or flowing well. If, however, the upper bed A, from extensive fissuring or a somewhat porous texture, be not water-tight, the pres sure will be relieved and the water will follow the more easily accessi ble channels through A to the surface, thus lowering the efficiency of the well at C. The head has in many instances been so reduced

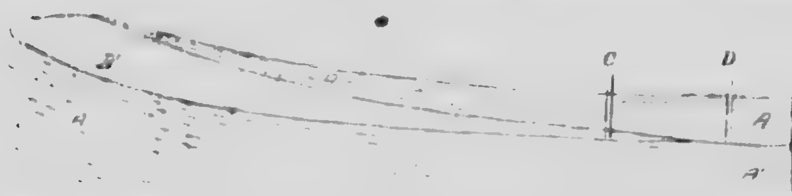

Figure 2. Showing the pinching out of the porous bed B. (Modified from Darton.)

Various types of structure in earth's crust which render artesian wells possible.

that the water will not rise to the surface but must be pumped. In such cases as these there must be a sufficient rainfall, and where the porous bed B outcrops, there must be a considerable area of the bed exposed. For instance, if the rainfall is the same at both the outcrops of B on the opposite sides of the basin, then ab, being more extensively exposed than cd, will furnish a greater supply of water.

Another type of structure and probably a more common one than that previously discussed, is shown in Figure 2. In this case there is no basin but a monocline or a long slope of the beds in one direction The porous bed B thins out and finally disappears, with a concurrent thickening of the impervious bed A. In such an instance a boring at C would be successful, while at D no water would be obtained. This structure obtains throughout the great coastal plain which forms the eastern margin of the United States, from New Jersey southward, and from it immense supplies of artesian water are obtained.

Again, the character of the surface drainage may be such as to interrupt the passage of underground waters, as shown in Figure 3, where a cross valley interrupts the water-bearing stratum. Little or ater would be obtained at B, while at A on the lower side of the y a successful well might be sunk. The water in the upper part . the bed about B would escape and probably form springs along the valley side at C. This is a condition frequently met with along the western border of the coastal plain in Maryland and southern Virginia.

Another case which is sometimes found is illustrated by Figure 4. Here the water-bearing zone, instead of being broad and continuous, is broken up into several narrow beds, which are flatly lenticular in cross section. Boring would give satisfactory results at C, but negative ones at D.

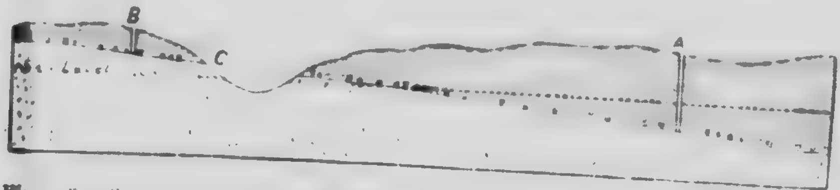

Figure 3. Showing effect of surface drainage on a porous bed. (After Darton.)

Many other types of underground drainage might be mentioned, but the above will suffice to explain the main conditions which affect underground waters traversing porous beds.

Figure 4. Showing the discontinuity of the porous stratum. (Modified from Darton.)

Artesian waters have however sometimes been obtained in districts which are underlain by rocks of a more massive character than those which we have been considering, such as compact limestones, granitic rocks and crystalline schists. The underground water in these cases flows through cracks and fissures and not through porous beds. This type of subterranean conditions is rudely represented in Figure 5, where the rocks at A are massive and crystalline, overlain by compact limestones, B. The gathering ground is the outcrop of these rocks at a, b, c, and the irregular lines indicate the courses of the subterranean water circulation which takes place through fissures. The supply of water in this case will not depend upon the amount of rainfall alone, but will be influenced by the extent of the subterranean erosion which the country has undergone, by which the fissures and

joint planes have been enlarged and deepened, so as to permit t
passage of large quantities of water along their course. In this instan
a well sunk at C would tap one of an upper series of fissures, and t
capacity of the well would be further increased if the boring we
extended to the lower level at C'. On the other hand, the boring
D would miss the water-bearing fissures by perhaps only a few fe
and would consequently be dry, as would also that at F. At E wat
is obtained from a lower series of fissures. The materials held
solution by the water in such a district would probably vary conside
ably, the variation depending upon whether the source of supp
was in the crystalline rocks or in the limestone, as well as on t
length of the underground channel through which the water had passe

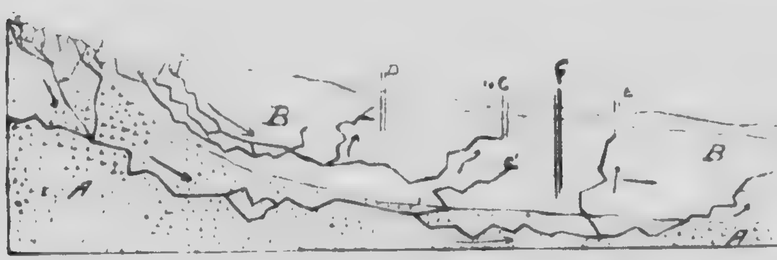

Figure 5. Showing the course of underground waters along fissures.

In Figure 5 the lower water-bearing fissures heading in the cry
tallines would probably contain soft water and rising directly throu
the limestones at E would be little influenced by the character of t
latter rock. This would serve to account for soft water when found
limestone districts. On the other hand, underground channels headi
in the limestone or traversing that rock for long distances would p
bably be hard and perhaps also saline or sulphurous. The well at
wou'd supply such a water. If, however, the well were deepened
C', a composite water derived partly from the lower set of fissures a
partly from the upper would be obtained.

Underground waters flowing through fissures.

In the case of waters whose underground flow is through fissures
great variation must always be looked for in the height to which t
waters will rise, not only in adjacent holes tapping different sets
fissures whose gathering grounds may be at very different elevatio
above sea level (as a, b, and b, c, in Figure 5), but also in ho
which tap different fissures of the same series. It will thus be se
that in such an area no definite predictions can be made concerni
the finding of water, owing to the irregularity in the course of t
water-bearing fissures. Even if the fissures be only a few feet ap

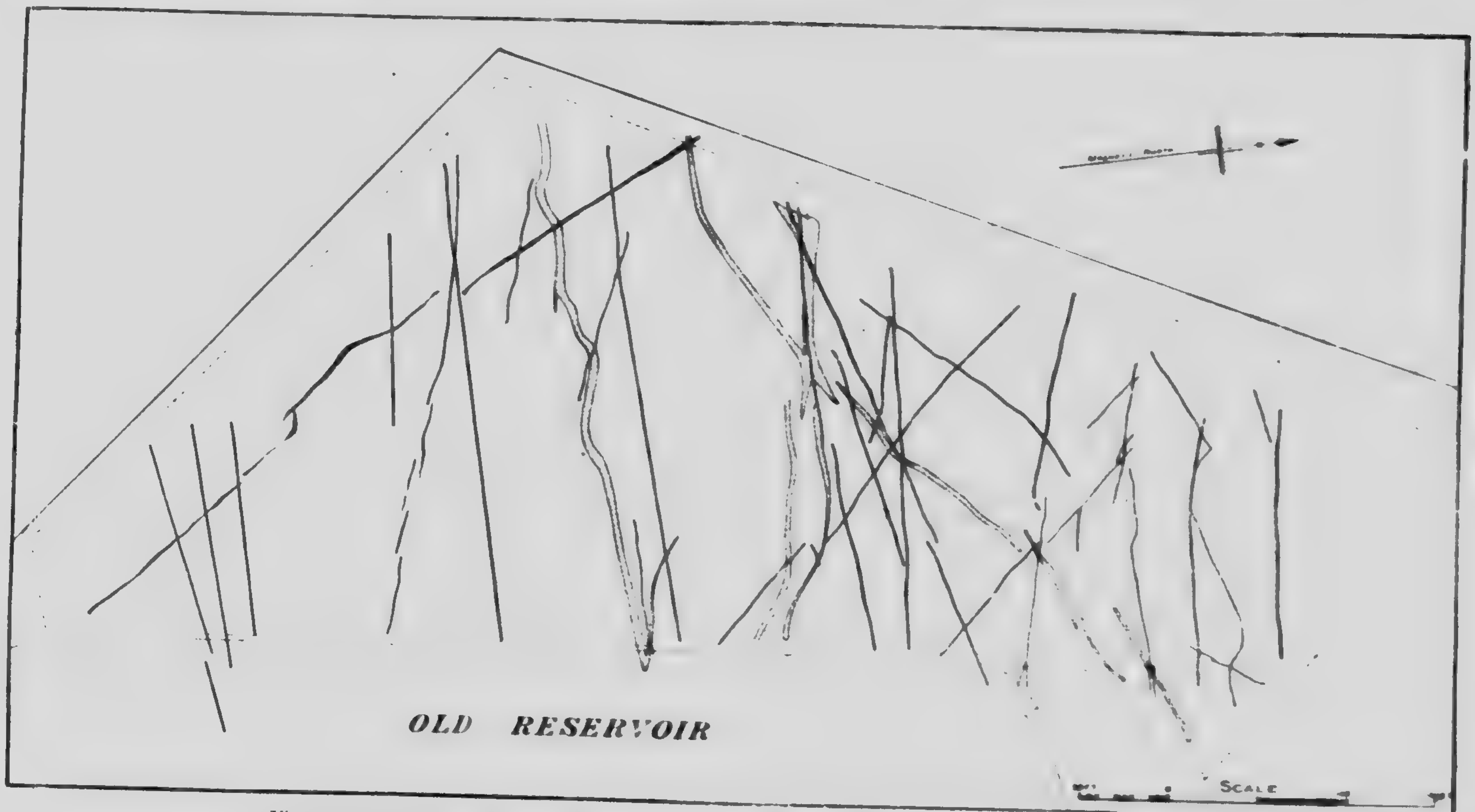

Figure 6. Map showing the dykes which cut the Trenton limestone at the Reservoir Extension, Montreal.

the number of unsuccessful wells will still be large. But in the c
of dry wells, as D, it might be possible by shattering the wall rock
some point along the course of the bore hole, making use of exp
sives, to open up a communication with some adjacent fissure and th
secure a supply of water.

A striking example of waters occurring in this manner is afford
by the islands off the coast of Norway. From the old crystalli
country rock there, large supplies of water are in many places obtain
by putting down deep bore holes which, meeting underground fissur
through which water is passing, afford a passage for the water to t
surface.

Conditions prevailing under the Island of Montreal.

Figure 5 also illustrates in a general way, as will be shown, t
underground conditions which prevail on the Island of Montreal whe
the bore holes are put down in heavily bedded limestones and whe
no constant and definite water-bearing horizons have as yet bee
reached. A further complexity, however, is introduced in this distri
by the existence of Mount Royal, the root of an old volcano, whic
with the swarm of dykes or walls of igneous rock connected with i
serves to make the course of the underground waters still more deviou

How abundant these walls of impervious rock really are and in wha
a complicated mesh-work they traverse the limestone strata of th
district may be seen in Figure 6 taken from a survey of the floor o
the newer portion of the McTavish Street reservoir, made by Dr. B
J. Harrington, many years since, when the reservoir was bein
enlarged. These dikes are found in almost every quarry and rock
cutting on the island, and may be seen in great numbers on St. Helen
island and in the bed of the St. Lawrence at Point St. Charles wher
the water is low.

A true artesian well must flow.

The term "Artesian well" is properly speaking used only to designat
a well which flows, without being pumped, the term being derived from
the French province of Artois where wells of this nature, put down in
the 12th century, first attracted widespread attention in Europe. Similar
wells, however, had long before been known in China, while others in the
Libyan desert are believed to be not less than 4,000 years old. In fact
there are few parts of the world where the geological conditions are better
suited to Artesian boring or where more abundant supplies of water
can be had, than over a great part of the North African desert. Under
the burning sand here, at a depth of 300-400 feet, there are abundant
supplies of water running through pervious sandy strata from the
richly watered district of the Soudan to the south, but held down by
an impervious limestone cover. It is only necessary to pierce the

latter to obtain for the water a passage to the surface, and the French engineers have turned great stretches of the desert into cultivated land by water obtained in this way.

Of recent years the Geological Survey of the United States has devoted a great deal of attention to the subject of Artesian water and immense supplies of excellent quality have been obtained in many parts of the Union to the great benefit of its inhabitants. In New South Wales, Queensland and other parts of Australasia also, search for Artesian water has resulted in securing immense supplies, and throughout the world generally attention has been strongly directed to this source of one of the chief requirements of life. Artesian wells in other countries.

The force with which the water issues from an Artesian well and the height to which it will rise above the surface, is dependent of course upon the height of the gathering ground above the level of the top of the boring. Other things being equal, the greater the difference in level the higher will the water rise. In the case of certain of the Artesian wells on the plains of Dakota, where the water has its source in the Black Hills and the Rocky Mountains, the water issues with a pressure of as much as 177 lbs. per square inch. One Artesian boring at Woonsocket, South Dakota, throws a 3 inch stream to a height of 97 feet. In many parts of this field the waters are known to run in the porous subjacent beds for several hundred miles before being brought to the surface. There are many Artesian wells in various parts of the world which yield half a million to a million gallons of water every 24 hours, while some of the great Queensland wells yield 2,000,000, 3,000,000 and even 4,000,000 gallons per diem. This yield, however, is exceptional. Enormous yields of wells.

In the case of many wells the pressure is barely sufficient to cause an overflow, while again in many instances wells must be pumped in order to bring the water to the surface. Wells of this last class, while often yielding an abundant supply of water, are not properly speaking Artesian wells, and to this class belong almost all the wells in the Island of Montreal, only six of the eighty-nine, above mentioned, being actually flowing wells, although in many of them the water rises to within a few feet of the surface. Most of the Montreal wells require to be pumped.

The water pressure naturally shows a marked tendency to become lowered when a large number of wells are bored in a limited area, especially when the water is derived from a porous bed of limited thickness. Thus, in London, England, where originally the water rose above the surface in all borings put down on the lower grounds of the valley of the Thames, now, owing to the multitude of deep

wells which have been sunk, the inflow of surface water cannot k pace with the quantity removed by pumping, and consequently water-level has been lowered to such an extent that it now sta about 100 feet below the surface of the Thames. Another strik instance is afforded by the area on which stands the city of Den Colorado. Here, the first Artesian well was sunk in 1883.

Pressure lowered when many wells are sunk in same district

"The flow yielded by the first well was so large, and the water of such superior quality for domestic use, that other wells were down with great rapidity. There are now (1889) in the city and vicinity about 300 wells. Many of the first wells had sufficient p sure to force the water into tanks, or to the tops of the highest bu ings in the city, but as the number of wells was increased the pres and flow of the older wells began to diminish, and finally in the re where they are most closely grouped they have failed to furnish w without the aid of pumps. Outside the region of closest grouping pressure and flow have been diminished, but not to so great an ext Deep wells are still bored at Denver, but not with the expectatio obtaining an Artesian flow.*"

Character of artesian water

Artesian water has comparatively little value unless it be fresh sweet, but in many cases the water obtained from Artesian boring saline and not potable. In other cases Artesian waters are very h owing to a large content of lime salts. This arises from the fact the waters have, during their underground journeys, passed thro beds containing salt, gypsum, limestone or other soluble materials have taken these into solution. In some cases also the waters h penetrated into the earth's crust to such a depth that they have bee heated by increased proximity to the central portion of the earth, rising again to the surface, produce warm springs. These, as wel many cold waters, frequently contain mineral matters in solu which are distinctly beneficial and not harmful, and thus the min waters, so largely used for medicinal purposes, result.

In the case of the district about Montreal, as will be shown these classes of waters have been obtained by deep borings, altho the water has not penetrated into the earth's crust in any case sufficient depth to be noticeably warm when it rises again to surface.

* Evidence of the Director of the United States Geological Survey before the mittee of the House of Representatives on Irrigation, Feb. 27th, 1890. Elev Annual Report, U. S. Geol Survey, pt. 2, p. 262. Washington 1891.

SKETCH OF THE GEOLOGY OF THE MONTREAL DISTRICT.

In the area embraced by the accompanying geological map of the Montreal district, there are two distinct and dissimilar tracts of country, each constituting a well-marked topographic facet or belt; these are the Laurentian plateau to the north west, composed of very ancient crystalline rocks, and the Palæozoic plain to the south. These two facets—only small parts of which are included in this map—have a wide development in Canada. Consists of two dissimilar tracts of country

The Laurentian plateau extends from Labrador south-west to Lake Superior, and thence northward to the Arctic Ocean, and has an area of over 2,000,000 square miles.* The plain bounded on the north by this plateau stretches from the Notre-Dame mountains, in Quebec, to Lake Huron and southward into the United States. The Laurentian plateau is a rolling, comparatively hilly and rugged country. That portion of it embraced within the limits of the accompanying map rises abruptly from the plain, the elevation becoming gradually greater on going to the north. At the north-west corner of the map it has an average elevation of about 600 feet above sea-level, while 15 miles further north the average elevation reaches 1,000 feet, and 25 miles still further north the country frequently attains an elevation of 1900 feet, while some hills rise still higher; the most notable of these is Trembling mountain the summit of which is 2,380 feet above the sea. The valleys are more or less filled with drift and in the hollows are numerous lakes, the abundance of the latter being one of the most characteristic features of the Laurentian highlands. Elevations

The Palæozoic plain is flat and thus offers a strong contrast to the topography of the plateau. The average elevation in the vicinity of Montreal is about 100 feet above sea-level, but there is a gentle rise towards the north-west, which gives the plain at its junction with the plateau an elevation of about 300 feet. The whole area is drift-covered and forms farming lands of exceptional fertility.

The continuity of the plain, within the area of the map, is broken only by Mont Calvaire at Oka, and by Mount Royal, rising behind the city of Montreal. The former is an outlier of the Laurentian plateau—an ancient island in the Palæozoic sea—and has an area of about 30 square miles, while the latter is the most westerly of a line of old volcanoes and laccolites, known as the Monteregian Hills†, Mont Calvaire and Mount Royal.

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* See A. W. G. Wilson: The Laurentian Peneplain. *Journal of Geology*, October and November, 1903.

† F. D. Adams: The Monteregian Hills; a Canadian Petrographical Province. *Journal of Geology*, April, 1903.

which cut the Palæozoic rocks of the plain. In the following b
description of the geology of the Montreal district only the sali
points concerning the different formations will be noted, the rea
being referred for more extended descriptions to the reports mention
in the foot note.*

THE LAURENTIAN PLATEAU.

Geological character.

This plateau is composed of a great complex of rocks, mainly
igneous (plutonic) origin, such as granites, syenites, gabbros, e
but also comprises some of the most ancient sediments of the eart
crust. Since their formation these rocks have suffered great alterati
being now folded, contorted, crushed and recrystallized. The therm
dynamic forces have destroyed their original structure, and substitut
for it a banded or schistose character. These metamorphic rocks
termed gneisses and schists, the designations being modified to indic
the composition of the particular rock under consideration; for
ample, granite gneiss, mica schist, amphibolite, etc.

The highly altered sediments folded in with these igneous roc
belong to what is termed the Grenville series. They consists of be
of rusty-weathering gneisses, impure crystalline limestones, gar
rock, amphibolites and quartzites, corresponding respectively to t
shales, limestones, calcareous shales and sandstones of unaltered se
mentary strata. This series is very important, not only as represe
ing some of the very earliest sediments on the surface of the ear
but because of the many minerals of economic value which it contai

Grenville series.

Subsequent to the Grenville period, but still in Laurentian tim
there was a great development of igneous activity along the southe
edge of the plateau, and great masses of anorthosite were intruded
the above-mentioned series. Portions of these are shown on t
accompanying map, at New Glasgow, St. Jérôme and in St. Colomb
respectively. Anorthosite is a gabbro made up almost wholly
Labrador feldspar. A later series of intrusions is represented by t
numerous dykes which cut all these older rocks. These dykes a
chiefly diabases and are pre-Potsdam in age and are thus quite distin
in character and age from those connected with the intrusions

* Geology of Canada, 1863. Chaps. 3, 4, 5, 6, 7, 8, 9, 10 and 13.

R. W. Ells: Report on a Portion of the Province of Quebec comprised in t
south-west sheet of the Eastern Townships. Geological Survey of Canada, Vol. V
1896; pp. 44-50, 74-75, 85-86.

F. D. Adams: Geology of a Portion of the Laurentian Area lying to the no
of the Island of Montreal. Geol. Survey of Canada, 1897; Part J.

Mount Royal. This plateau, composed of crystalline rocks of Laurentian age, was part of the primitive continent of North America and formed one of the nuclei about which the continent as now seen was built up.

THE PALÆOZOIC PLAIN

At the beginning of the Lower Silurian era of Palæozoic time the Laurentian plateau, standing at a certain elevation above the sea which then covered the plain, was acted upon by the various agents of erosion and decay, both sub-aerial and marine. The accumulation of debris derived from the waste of the Laurentian continent was assorted by the waves and deposited in the sea along the flanks of the primitive continent. Thus a series of stratified rocks was laid down on the sea floor, and on these other sediments from the ocean were subsequently deposited, forming what is known as the Lower Silurian or Ordovician system. These rocks underlie the plain.

The formations of the Lower Silurian are the following, enumerated in ascending order:— Palæozoic formations.

Potsdam Sandstone.

Calciferous Sand-rock.

Chazy Limestone.

The Trenton Group—consisting of limestones.

Utica Shale.

Lorraine (Hudson River)—consisting of shales and sand

Potsdam Sandstone.

The *Potsdam Sandstone* was the first formation laid down on the Archæan floor. It is represented in type by the modern sand and gravel deposits which flank our coasts. Its lowest members are beds of conglomerate, holding pebbles of Laurentian gneisses and quartzites. These beds pass upwards into evenly stratified, fine-grained, and very quartzose sandstones. It is distinctly a shallow water formation and many layers show false bedding, ripple marks, with tracks and burrows of animals which crawled upon the shallow sea bottom or burrowed in the sand. The formation in this district flanks the Laurentian plateau, first as a narrow band, which, broadening out in its southern extension, embraces the old island of Mont Calvaire and extends southward into the counties of Vaudreuil, Soulanges and Beauharnois. Ile Perrot is wholly underlain by the Potsdam and Potsdam sandstone.

there are small exposures on the Island of Montreal at Ste. Anne Bellevue, where fine worm burrows and ripple marks are to be seen the nearly horizontal beds. The thickness of the formation varies f 300 to 700 feet.

Calciferous Sand Rock.

Calciferous.

A slow sinking of the Laurentian plateau was in progress from beginning of the Potsdam period, and as a consequence, the succeed formation, the Calciferous, representing deeper water conditions, im diately overlies the Potsdam, the two being united by transiti beds, so that the lower formation insensibly graduates into the up Marine life was more abundant during this period, as evidenced the number of fossils inclosed in the Calciferous. Gastropods snails), Cephalopods (ancient types of devil- or cuttle-fish), and m forms of Brachiopoda found a suitable environment in the calm wa of the Calciferous sea.

The rock itself varies somewhat in character, but usually is a g ish, semi-crystalline dolomite or magnesian limestone, which is g rally arenaceous or siliceous and occasionally argillaceous. In m instances it holds geodes of quartz and calcite, and irregular str and patches of black chert.

In horizontal distribution it succeeds the Potsdam, forming a sec belt along the margin of the old continent, and is well developed in counties of Terrebonne, Two Mountains, and on the north-west of Ile Jésus, the west ends of Ile Bizard and the Island of Montreal, south of Lake St. Louis and in the county of Beauharnois. F surface measurements the thickness of the formation seems to vary f 300 to 450 feet.

Chazy Limestone.

Chazy limestone.

In the Chazy time, with a farther deepening of the sea, the condit became more truly oceanic, and there was consequently a great d lopment of marine life, particularly of the Brachiopoda. These, thro the accumulation of their shells, built up extensive beds of limest many of the latter consisting almost wholly of the shells of a si species, Rhynconella plena.

The formation is represented by granular, semi-crystalline light dark gray limestones, made up in great part of shells and their minuted fragments. Interstratified with the limestone beds occasional shaly layers which indicate the influx of muddy wa into the prevailingly clear waters. In geographical distributio

formation appears as a narrow sinuous band following the Calciferous and which broadens out as it crosses the middle of Ile Jésus and the Island of Montreal. From the southwest end of Ile Jésus, another body passes across Ile Bizard and the west end of the Island of Montreal, and thence passing beneath the waters of Lake St. Louis occupies an area extending from Chateauguay and Caughnawaga to the southern limit of the map. The field relations give the Chazy a thickness of about 300 feet.

Trenton Group.

The Trenton group, into which the Chazy insensibly merges, consists of three divisions which, in ascending order, are known as the Bird's Eye, Black River and Trenton formations. As the Bird's Eye and Black River divisons are not especially well developed in the vicinity of Montreal, no attempt has been made to separate them in mapping and hence the whole group is represented by one colour. Trenton group.

The Trenton is one of the most persistent and conspicuously marked series of strata of the Lower Silurian in North America, and judging from the abundance of the remains of marine invertebrate life this period evidently represents long continued and truly oceanic conditions, the waters being clear and probably warm. In addition to numerous representatives of previously mentioned marine families, Trilobites and Corals flourished, the latter especially giving rise to great beds of limestone.

The rock is usually a granular, semi-crystalline, dark gray limestone, more or less bituminous, and contains a variable amount of argillaceous (clayey) material. In many instances the limestone beds are separated by thin partings of shale, these being thicker and more pronounced at the top of the series where the Trenton passes into the Utica formation.

The Trenton group runs in a rather broad band from L'Assomption to south of the St. Lawrence. It is extensively developed in the vicinity of Montreal, and immediately underlies the city. In the district about Montreal it was supposed by Logan to have a thickness of about 300 feet.

Utica Shale.

The marine conditions prevailing in the Trenton were succeeded in Utica times by a gradual elevation of the sea bottom, and the clear deep water of the former period became shallow and muddy. This change of conditions was not favourable to the existence of those forms Utica shale.

of life which flourished in the Trenton, consequently they, for the m part disappeared, their place being taken by forms of life adapted cold and muddy waters. The Utica formation consists of thi laminated black and brownish black shales often bituminous and whi are very brittle, usually breaking up where exposed to the weath into small thin fragments. The formation occurs only in the easte part of the area embraced by the accompanying map, following t course of the River St. Lawrence. On the Island of Montreal extends from Verdun to Point St. Charles. There is also a sm area at the north end of the island. It underlies the harb of Montreal and forms the south end of St. Helens island. Its ma mum thickness is about 300 feet.

Hudson River or Lorraine Shale.

Hudson River shale.

The Utica formation passes upwards into the less bituminous a sandy shales and the thinly bedded sandstones of the Lorraine. T conditions of deposition must have been somewhat similar to those the Potsdam period, except that the sands were mixed with cl instead of being purely arenaceous.

The Lorraine has a thickness of about 2000 feet and is develop along the extreme eastern margin of the map.

These lower Silurian formations, from the Potsdam to the Lorrai in this area, have been but little disturbed. Over the greater part the area they either retain their original horizontal position, or dip the south-east at a low angle, seldom exceeding 5 degrees, The Cha and Trenton on Ile Jésus and Montreal island, however, display low anticlinal arch, the axis of which runs north-west from Mou Royal. This is traversed by two others, one on each of the island with axes almost at right angles to the main anticline.

Another anticline with an axis running north 23 degrees west seen in the western portion of the area, the central part or dome which is occupied by the Archæan outlier of Mont Calvaire. Betwee Mont Calvaire and the border of the Laurentian plateau, the outcro of the Potsdam and Calciferous gives to the former the outline of a hour-glass.

The Igneous Intrusions of Mount Royal.

Mount Royal.

During the Devonian or post-Devonian time that part of the Palæozoi plain in the vicinity of Montreal was the scene of great volcanic acti vity, the present evidences being the line of igneous hills whic extend from Shefford to Mount Royal. These hills, greatly reduce

in size and representing merely roots of the original volcanoes or in some cases uncovered laccolites, by reason of the flatness of the plain, form striking topographic features, and are locally known as mountains.

Essexite and Nepheline Syenite Intrusions.

The igneous mass of Mount Royal occupies an area of about one and a half square miles, and is surrounded by the Trenton limestone, through which it has broken, and which by it has been in many places altered to marble. The main part of the mountain is composed of Essexite, a plutonic rock composed essentially of plagioclase feldspar, augite and hornblende, with a little nepheline. Olivine is in some places present as an accessory constituent. This Essexite was subsequently cut through by a later intrusion consisting of Nepheline syenite, a rock which is genetically related to the former and which consists essentially of orthoclase feldspar, nepheline and hornblende. It represents a more acid phase of the original magma. The Nepheline syenite appears as a comparatively broad band along part of the north-west flank of the mountain. This intrusion is quarried at Outremont for road metal and is of particular interest in that it has furnished a number of rare minerals, that most recently discovered being Native Arsenic*

Dykes and Sills.

Associated with these intrusions is a great swarm of dykes, that is to say, more or less steeply inclined or vertical walls of igneous rock, which cut both the Essexite, Nepheline syenite and the surrounding stratified rocks in all directions. There are also numerous sills or sheets of the same, intercalated between the beds of the stratified rocks. These dykes and sills consist of a complete series of those rarer varieties of dyke rocks which belong to the Nepheline syenite—Essexite magma and which are known as Bostonite, Camptonite, Alnoite, Tinguaite, etc. They are related genetically to the former intrusives and represent the closing stage of the volcanic action. The dykes may be seen in almost all large exposures of rock in the vicinity of Montreal, as for instance in Mount Royal Park, the Corporation Quarry at Outremont, the Mile End Quarry, or on St. Helens island.

The most westerly representative of this series of igneous rocks, connected with the volcanic centre of Mount Royal, is found on the south east flank of Mont Calvaire. Its relations to the mass are not well seen, but it is either a broad dyke or a sill which cuts through the massive crystalline limestone of the Laurentian on the north and a body of pegmatite on the south; the intrusion in each case running into the wall-rock and holding an immense number of included frag-

* Evans, N.N.: Native Arsenic from Montreal. Amer. Jour. of Science. Feb. 1903.

ments. The rock bears a marked resemblance to that of the known occurrence of alnoite which is found as a dyke cutting Potsdam sandstone at the bottom of the Ottawa river opposite Anne de Bellevue.*

In order to show how numerous these dykes are in certain p about Montreal and the complicated manner in which they cut another, there is presented in Figure 6, a small scale map af an now covered by the waters of the Montreal Reservoir on McTa street, which was surveyed by Dr. B. J. Harrington some thirty y ago during the construction of the reservoir. As will be seen t are here within an area about 200 yards in length by 100 yard width, not less than 46 dykes, belonging to some seven different se each series cutting those older than itself.

Their influence on underground waters.

These dykes in their underground extension, forming imperv walls crossing the fissures through which water runs, certainly ha very important influence locally in determining the courses taken the subterranean waters.

At several localities about the Island of Montreal, a peculiar bre occurs which is evidently connected with the Mount Royal intrus It is found on St. Helens island and Ile Ronde, Ile Bizard, at W Horse rapids, Rivière des Prairies, and on the east flank of M Calvaire, apparently overlying respectively the Utica, Chazy, Tren and Potsdam formations. It also occurs in fissures at Pointe Clair the Chazy, and at McGill College in the Trenton. Its best deve ment is on St. Helens island. The breccia is massive and unstr fied and consists of angular and rounded fragments of gneiss, quartz limestone, red and gray sandstone, shale and hornstone, imbedded dark gray matrix of impure dolomite.

These fragments represent a vertical range in the geological ti scale extending from Laurentian to Lower Devonian, for two la masses of limestone included in the breccia are respectively Lo Helderberg (Upper Silurian) and Lower Devonian in age. The for corresponds chronologically to the Upper Pentamerus zone of East New York, and the latter to the Oriskany formation as exposed Western Ontario and Virginia as shown by a detailed palæontolog study of the occurrences recently made by Dr. H. S. Williams. I

Volcanic ejectamenta on St. Helens island.

believed that in these areas of breccia are preserved the last surviv remnants of the ejectamenta of the volcano of Mount Royal, and t

*F. D. Adams : On a Melilite-bearing Rock (Alnoite) from Ste Anne de Belle near Montreal, Canada. *Amer. Jour. Sci.*, April, 1892.

on St. Helens island is of especial interest as presenting conclusive evidences of the extension of the Upper Silurian and Devonian seas as far north as Montreal.* The breccia is cut by several dykes, which proves that it was formed before the volcanic activity had entirely ceased.

Pleistocene.

Between the Devonian and the Pleistocene a great gap exists here in the geological record, the upper part of the Palaeozoic and the whole of the Mesozoic and Tertiary being unrepresented. Pleistocene deposits.

During Pleistocene time, however, it is known that an Arctic climate prevailed and that the area was covered by the great ice sheet known as the Laurentian glacier, which gave rise to certain deposits characteristic of glacial action. These drift deposits consist of clays, sands and gravels, the lowest member being the boulder clay ("hard-pan") composed of glaciated boulders embedded in a fine clay or rock-flour. This is very compact and resists erosion as readily as many of the old stratified rocks. The upper members of the drift, which are stratified clays, sands and gravels, were formed during a post glacial submergence, which followed the retreat of the ice sheet. In the vicinity of Montreal they are known as the the Leda clay and Saxicava sands and gravels. From the abundant fossil remains (shells) in these marine deposits, it is inferred that the climate was sub-arctic, as closely related species (in many cases identical) are now found living off the coast of Labrador.

This marine submergence was very widespread, the sea level reaching a height of at least 625 feet on Mount Royal and covering the entire plain.

As the land slowly rose again, the sea retreated, and marked by a terrace each level at which it remained stationary for a time. In this way the series of terraces, encircling Mount Royal mark the successive stages of emergence from the Pleistocene sea. These terraces are well developed at Montreal between the Mountain and harbour, the most prominent ones being those on which Sherbrooke street and St. Catherine street are located, and which form striking features in the landscape along the banks of the St. Lawrence both to the north and south of the city. Terraces.

The accompanying table presents the chief characteristics of the above named formations in tabular form.

* A. W. Nolan & J. D. Dixon: The Geology of St. Helen's island. Can., Record of Science, Vol. IX, No. 1, p. 53 (1903).

SYNOPTICAL TABLE OF GEOLOGICAL FORMATIONS ABOUT MONTREAL, CANADA.

By Henry M. Ami, and Frank D. Adams.

System.	Formation.	Character of Strata, etc.	Characteristic Fossils.	Thickness as determined from surface outcrops.	Localities.
	Recent. (Sorel.)	Alluvium, river and lake deposits, silts, shell-marl deposits.	Goniobasis livescens, Planorbis parvus, P. trivolvis, P. bicarinatus, Unio complanatus, U. rectus.	Varies from a few inches to 30 and 40 ft.	Pte. aux Trembles, Boucherville Islands, shores of St. Lawrence and submerged portions of islands adjoining.
POST-TERTIARY OR QUATERNARY.	Champlain. Saxicava.	Light yellow or ferruginous sands.	Saxicava rugosa, Linnaeus. Macoma fragilis, Fabricius.	From a few ins. to several ft.	St. Louis and Mile-End Quarries, the Tanneries, terraces along Craig street, Beaver Hall Hill, Sherbrooke and St. Denis st. at different elevations.
	Champlain. Leda Clay.	Bluish-gray, fine grained plastic or stiff clays and muds, brown and dark coloured.	Yoldia limatula; Portlandia arctica; Mytilus edulis, Linnaeus.	From a few ins. to 50 ft.	
		Glacial and boulder clays, 'till', clay and sand and rock fragments derived from older formations.	None detected as yet.	From a few inches to upwards of 100 ft.	Along Lachine canal, Hochelaga, abounding, underlying the Leda clay almost everywhere.
POST-DEVONIAN	Intrusives.	Nepheline Syenite, Essexite, Camptinite, Tinguaite, Alnoite, etc.,		Forming conspicuous masses breaking	Mount Royal, Montarville, Rougemont, Beloeil, Mt. John

POST-DEVONIAN	INTRUSIVES.	Nepheline Syenite, Essexite, Camptinite, Tinguaite, Alnoite, etc., Breccias.		Forming conspicuous masses breaking through the [illegible]	Mount Royal, Montarville, Rougemont, Belœil, Mt. Johnson, St. Helens Island [illegible]
		[illegible]	[illegible] Spirifer [illegible]	[illegible]	[illegible] St. Helens island, as
DEVONIAN.	ORISKANY.	Impure fossiliferous limestone.	Metaplasia pyxidata	Isolated patches and fragments.	fragments in the breccias or volcanic agglomerates of Post-Devonian age.
SILURIAN.	LOWER HELDERBERG.	Light gray impure subcrystalline and altered limestone as small outliers.	Camarotœchia ventricosa, Gypidula pseudogaleatus, Spirifer concinnus, Rensselaeria mutabilis.	Not ascertained.	St. Helens island, as fragments in the breccias. Belœil mountain.
			Leptæna rhomboidalis; Stropheodonta varistriata; Strophonella punctulifera; Pentamerus (Sieberella) galeatus, Atrypa reticularis, Platystoma depressum.	Isolated patches.	
ORDOVICIAN.	LORRAINE.	Black or dark brown and buff weathering shales and arenaceous beds and mudstones. Fossiliferous.	Favistella stellata, Orthograptus quadrimucronatus, Zygospira Headi, Pterinea demissa, Byssonychia radiata, Clidophorus planulatus, Orthodesma parallelum. Protowarthia cancellata, Cyrtolites ornatus.	From a few feet to 2000 feet.	Chambly; St. Lambert, Rivière des Hurons; L. A. 5, Con. 3 Chambly Canton; Rougemont, Belœil stat'n.
	UTICA.	Dark brown and black bituminous shales or pyroschists with impure limestone bands at base.	Leptograptus flaccidus, Leptobolus insignis, Schizocrama filosa, Cornulites immaturum, Endoceras proteiforme, v. tenuistriatum, Triarthrus Becki, Trocholites ammonius.	Between 100 and 300 feet.	South end of St. Helens island; St. Lawrence Riv. bed and shores near Lachine Hydraulic Co.'s works; Victoria bridge, below piers.

SYNOPTICAL TABLE OF GEOLOGICAL FORMATIONS ABOUT MONTREAL, CANADA—*Continued.*

By Henry M. Ami, and Frank D. Adams.

System.	Formation.	Character of Strata, etc.	Characteristic Fossils.	Thickness as determined from surface outcrops.	Localities.
ORDOVICIAN.	Trenton.	Dark gray impure fossiliferous limestones and shales extensively quarried for building purposes. At times semi crystalline.	Glyptocystites Logani, Heterocrinus tenuis, Pachydictya acuta, Phyllopora Trentonensis, Prasopora Selwyni, Plectambonites sericea, Trematis Montrealensis, Dalmanella testudinaria, Lingula riciniformis, Parastrophia hemiplicata, Rafinesquina alternata, Platystrophia lynx, Cyclonema Montrealense, Trochonema umbilicatum, Conularia Trentonensis, Trinucleus concentricus, Isotelus gigas, Calymene senaria.	About 500 feet.	Montreal, Hochelaga, Pte. aux Trembles, Lachine, St. Louis and Mile End quarries.
	Black River.	Light gray weathering, dark gray and black impure fossiliferous limestones. Building stone.	Tetradium fibratum, Columnaria Halli, Stromatocerium rugosum, Helicotoma planulata, Cyrtodonta Huronensis, Bathyurus extans.	About 75 feet.	Pointe Claire quarries, St. Vincent de Paul
	Chazy.	Light and dark gray semi-crystalline impure fossiliferous limestones useful for building purposes.	Bolboporites Americanus, Malocystites Murchisoni, Blastoidocrinus carchariædens, Camarotoechia plena, Hebertella borealis, Dinorthis platys, Bathyurus Angelini.	Between 150 and 300 feet.	Back River north of Mt. Royal, Sault au Recollet, St. Martin, Bord à Plouffe, Terrebonne, Caughnawaga.
	Calciferous.	Dark gray buff and yellow weathering impure earthy and semi-crys[tal-]	Orthisina grandæva, Billings, Pleurotomaria Calcifera B. P. Canadensis, B. Hormotoma Anna, B. Metoptoma	Between 300 and 450 feet.	Ste. Anne quarries at railway station and

		[illegible]	[illegible]		[illegible] Caughnawaga.
	CALCIFEROUS.	Dark gray buff and yellow weathering impure earthy and semi-crystalline limestones, for[illegible] cavities. Lower measures arenaceous.	Orthisina grandæva, Billings, Pleurotomaria Calcifera B. P. Canadensis, B. Hormotoma Anna, B., Metoptoma simplex, B., Orthoceras Lamarcki, B. [illegible] Ampullaria Anna B.	Between 300 and 450 feet.	Ste. Anne quarries at railway station and east of village, [illegible] about Lake [illegible] village.
	POTSDAM.	Light yellow and rusty weathering sandstones and conglomerates occasionally present at the base and along certain divisional planes of stratification.	Scolithus Canadensis, Bill., Protichnites multinotatus, Owen; P. lineatus, Owen., P. octonotatus, Owen, P. septem-notatus, Owen.	Between 200 and 700 feet.	Western extremity of Island of Montreal at Ste. Anne De Perrot, Beauharnois, Vaudreuil, etc.
LAURENTIAN.	MORIN INTRUSIVES: "NORIAN."	Anorthosites, foliated gabbros.		Large body having area of 990 square miles & smaller ones several penetrating older masses.	St. Agathe, St. Edith, Kilkenny, Morin, Lakefield area, St. Jerome.
	GRENVILLE SERIES.	Crystalline limestones, gneisses and quartzites	None.	Thickness of crystalline limestone and quartzite bands varys constantly.	District south of Randon; St. Sauveur district.
	Lower Laurentian. (FUNDAMENTAL GNEISS).	Foliated gneiss, [illegible] granitoid gneiss, a[illegible] gneiss.	None.	Forming masses of igneous origin with indefinite thickness.	Oka, St. Columban, St. Jerome, St. Canut.

CLASSIFIED LIST AND DESCRIPTION OF THE W WHICH HAVE BEEN PUT DOWN ON THE ISLAND OF MONTREAL.

Report includes all wells put down prior to close of the year 1903.

In this section a list and description is given of all the bo far as can be ascertained, which had been put down on the Montreal, up to the close of the year 1903. As will be se are eighty nine in number. It is just possible that some oth have been put down whose existence has escaped the attentio writers and which are not here recorded. If so, these are ver number, as the search for these wells has been a thorough one list is believed to be complete.

In many cases the information obtained covering individu is very meagre, and in no case is it as full as could be desi every case, however, all the information which it was possible has been presented.

The borings are classed under three heads: those yiel Potable Water, those giving (2) Sulphuretted or Saline Wa (3) Dry Wells. This classification is more or less arbitrary waters are slightly sulphuretted and lose their odour on stan a time, while others are highly charged with sulphuretted hy It is difficult, therefore, especially in the absence of detailed analysis, in many cases to determine in which class a water sh placed. The character of a water, however, cannot be seriou judged, even if it happens to have been placed in Class I, belongs rather to Class II, or *vice versa*, since the descript serve to show its character so far as this is known.

Eighty-nine wells,

Again, the term "dry well" is one which may be defined in ways. None of these wells were absolutely dry. In all cases water oozed into the hole to allow the boring to be readily car Such borings, however, although wet, yield no supplies of wate could be pumped. Other wells again would yield two or three t gallons a day. This yield may be sufficient for the very m needs of a farmer, for instance, but it would be useless in the a large manufacturing establishment. In fact, a well which yield over 5,000 gallons per diem is considered by the well dri be a "dry well."

Classification of wells.

When a well is drilled its capacity is determined by pumpin several hours and thus ascertaining the amount of water which yield. The values given as 'capacity per diem in gallons'

accompanying tables, are arrived at by taking the number of gallons pumped per hour and multiplying by twenty four. The capacity thus stated may therefore in some cases be in excess of the actual per diem capacity of the well, but the amount of water stated by the drillers to have been actually pumped in the trials made on the completion of the well is given in the text in each case where a trial was made—and may be there ascertained.

Method of determining the yield.

The capacity of many of the wells has not, however, been actually determined. In certain cases if the well yielded the small amount of water required, this was considered to be quite satisfactory and no test was made as to the full yielding power or capacity of the well. In these cases it is impossible to apply the well drillers' definition. It has therefore been considered best to use the term 'dry well' in the sense of a well which would not afford any supply of water, but in calculating the proportion of wells which give adequate supplies of water as compared with the total number of wells put down, an adequate supply has been considered to be 5,000 gallons per diem. Under each heading the wells have been arranged in alphabetical order—for convenience of reference—quite independent of their location on the island.

On the accompanying map of the City of Montreal and vicinity the location of each well is indicated by a coloured dot, the colour employed in each case showing whether the water is Potable, Sulphuretted or Saline, or whether the boring was a Dry one.

Several sets of wells are on this map connected by dotted lines, and the sections of the wells of each set are plotted on the accompanying set of diagrams (figures 7 to 10), thus showing clearly the comparative character of groups of adjacent wells.

Definitions of terms used.

In the tabulated list the wells of all three classes are put together and arranged in alphabetical order and the chief facts concerning them are given. In this list the potable waters are marked "good" when they are known to be potable, but when nothing further is known concerning their nature. When their character is known more definitely they are marked "soft" or "hard". The saline or sulphuretted waters are entered as such.

Tabulated List of the Artesian and other

No.	Name of Owner	Location	Depth in ft.	Diameter of bore in inches
1	R. B. Angus	Ste. Anne de Bellevue .	222	4½
2	Armstrong & Cook	Montreal West	500	
3	Beding, Paul & Co	On Canal, near Seigneur St Bridge.	548	6
4	Bushnell Oil Co	Ville St. Louis	305	
5	C. S. Campbell	Dorval	400	4½
6	Canada Brewing Co	218 Delorimier Ave	500	.
7	The Canada Malting Co	St. Henri (lot 1047-81)	678	6 & 4½
8			566	.
9		"Abattoir Site", near St. Henri.	1281	4½
10	The Canada Sugar Refining Co	150 Montmorency St	312	.
11	Canadian Pacific Railway	Hochelaga	580	8 & 6
12	"	"	557	8 & 6
13	"	Outremont .	410	5½ & 4
14	Convent of the Precious Blood	Notre Dame de Grâce	206	. .
15	M. Cousineau ...	St. Laurent	128	.
16	Dr R. Craik	Petite Côte, lot 192	305	4
17	Mr. Curran's Farm	Between St. Laurent & Back River	250	6
18	The Thomas Davidson Manufacturing Co	187 Delisle Ave., Ste. Cunegonde	150	6
19	Dawes & Co ..	Lachine	1003	.
20	W. B. Dickson	Longue Pointe, lot 21	170	..
21	The Dominion Wadding Co.	Cor. Williams & Vinet Sts. Cunegonde . . .	175	6
22	William Dow & Co . .	186-188 Colbourne St .	300	4½
23	" " . .	"	420	4½
24	" " . . .	" "	430	
25	" " . .	Same property—cor. of Inspector St.	830	4½
26	Alex. Drummond ..	Petite Côte	500	......
27	Sir. G. A. Drummond. ...	Beaconsfield ...	425	. ...
28	J. N. Drummond	Petite Côte, lot 195	223	.. .
29	H. A. Ekers	Petite Côte, lot 208	325	.
30	Ekers' Brewery	400 St. Lawrence St	600	....
31	Excelsior Woollen Mills	967 Ontario St	812	6 & 4
32	Excelsior Woollen Mills ...	967 Ontario St....	751	10 & 6
33	Excelsior Woollen Mills ..	967 Ontario St . ..	300	....
34	The Fenlin Leather Co... .	141 Frontenac St	1025	....
35	M. Galibert.	920 St. Catherine St	454	4
36	H. Gatehouse	808-810 Dorchester St	750	.... .
37	Globe Woollen Mills..	219 Delorimier St	410	. ... .
38	The Gould Cold Storage Co.	Grey Nun & William Sts	1301	......
39	" "	" "	500	.. ....
40	A. Goyer....	Frontenac St.......	375	4½
41	F. Goyer	Côte des Neiges............	250	4½
42	M. Groboyau ..	1675 Papineau ave	350	....
43	Chas. Gurd	39 Jurors St	512	....
44	Mr. Hampson	Longue Pointe, lot 40.......... ..	502	....
45	A. Hobbs	Outremont (back of C.P.R. Round House)........................	240	6
46	Edward Hughes	Côte St. Michel................ .	75	....

Deep Wells on the Island of Montreal

Capacity per diem in gallons	Water level in feet	Character of water	Remarks
18,000	12	Good	
10,000	100	Hard slightly sulphurous	Rock 50 feet from surface.
21,000	10	Hard	Rock 64 feet from surface.
1,000	200 30	Hard slightly sulphurous	Rock at surface.
12,000	20	Good	
24,000	28	Good	Rock 50 feet from surface.
12,000	6	Good	Water was obtained at 900 feet. Rock 32 feet from surface.
16,000	40	Good	Rock 18 feet from surface.
18,000	10	Highly saline	Water at 300 feet and no further supplies below. Rock 30 feet from surface.
120,000	18	Good	Rock 70 feet from surface.
240,000	6	Good	Rock 12 feet from surface.
120,000	8	Good	Rock 13 feet from surface.
192,000	8	Hard & sulphurous	Rock 25 feet from surface.
35,000	20	Good	Rock 12 feet from surface.
abundant	7	Rather hard	Rock 40 feet from surface.
120,000	10	Soft	
24,000	6	Pure	Rock 16 feet from surface.
72,000	8	Hard	Rock 50 feet from surface.
abundant	10	Saline	
	13	Saline & sulphurous	Rock 100 feet from surface.
abundant	8	Pure	Water at 100 ft. Rock 90 feet from surface.
24,000	50	Not sulphurous	
to small to be of any value	40		
60,000	30	Slightly sulphurous.	
hardly any water			
8,400	50		Rock 5 feet from surface.
36,000	10	Hard	Rock 10 feet from surface.
24,000	25	Soft, slightly sulphurous.	
14,000	33	Rather hard	
25,000	10	Good	Rock 70 feet from surface.
5,000	100	Good	Water obtained at about 600 feet.
86,000	20		Rock 35 ft. from surface. Some water at 500 ft.; further supply at 740 feet.
no water			
too small to be of any value (4800)			Rock 60 feet from surface.
25,000	5	Good	Rock 56 feet from surface.
20,000	30	Good	Rock 46 feet from surface.
65,000	10	Hard	Rock 35 feet from surface.
10 000	40	Good	Rock 73 feet from surface. All the water obtained was struck at 360 feet.
none			
9,000	10	Soft	Rock 30 feet from surface.
72,000	-10	Very hard	Rock 25 feet from surface.
abundant	12	Soft	Rock at surface.
800 without pumping	0	Sulphurous	Water at 440 feet and at 512 feet, 4000 gals. can be pumped.
		Saline & sulphurous.	
48,000	0	Good	Rock 5 feet from surface.
19,000	20	Soft	Rock at surface.

Tabulated List of the Artesian and other

No.	Name of Owner.	Location.	Depth in feet	Diameter of hole in inches
47	Laing & Sons	Cor. St. Catherine & Parthenais Sts	325	......
48	Laurentian Baths	208 Craig St	280	6 & 4¾
49	Laurie Engine Company	1020 St. Catherine St	300	6 & 4¾
50	Laurie Engine Company	1012 St. Catherine St	700	..
51	Longue Pointe Asylum	Longue Pointe	2000	..
52	Lovell & Christmas	63 William St	612	6
53	A. Martin	Lachine, lot 1010	740	6
54	A. S. & W. S. Masterman	2082 Notre Dame St	800	..
55	Mrs. J. McIntosh	Côte St. Michel	120	..
56	J. H. R. Molson & Bros	1006 Notre Dame St.	674	8½ & 4¾
57	Montreal Brewing Co	1334 Notre Dame St.	502	4½
58	Mount Royal Cemetery	Near Crematory	354	1¼
59	Montreal Cold Storage Co.	610 St. Paul St	1020	..
60	The Montreal Gas Co.	Hochelaga	1850	..
61	" "	"	2[illegible]0	..
62	" "	Ottawa St	1050	..
63	Montreal Hunt Club	Outremont	226	6
64	Th[illegible] Montreal Locomotive & Machine Co.	Longue Pointe	514	..
65	Montreal Milling Co.	Park Ave., Outremont	345	5
66	Mount Royal Park	"Park Well"	66	4
67	Montreal Weaving Co	595 Clarke St	420	..
68	G. Nantel	Côte des Neiges	600	..
69	Outremont Milling Co.	Outremont	335	4
70	Judge Pagnuelo	Pagnuelo Ave.	700	..
71	Mrs. Quiggley	Longue Pointe	100	..
72	A. Ramsay	Inspector St	800	..
73	A. Ramsay	Westmount	880	..
74	M. Rheaume	Carrière St.	300	..
75	Rowan Brothers	618 Beaudry St	600	..
76	The Royal Golf Club	Dixie	450	..
77	The Salvador Brewing Co.	617 St. Paul St.	550	4½
78	Sault au Recollet College	Back River	490	6
79	Shawinigan Water & Power Co	Maisonneuve	1017	..
80	Sisters of Providence	Notre-Dame de Grâce	320	4½
81	Stanley Dry Plate Co.	613 Lagauchetière St.	1300	4¾
82	St. Laurent Convent	St. Laurent	250	..
83	St. Laurent College	"	487	..
84	Mr. Stewart	Petite Côte, lot 195	223	..
85	T. A. Trenholme	Côte St. Pierre, lot 141	185	..
86	T. A. Trenholme	Thorne Hill, Côte St. Pierre	175	..
87	Turkish Baths	140 Ste-Monique St.	1550	..
88	Viau et Frères	Maisonneuve	1500	..
89	The Wire & Cable Co.	233-241 Guy St.	1055	6 & 4¾

Deep Wells on the Island of Montreal—*Concluded.*

Capacity per diem in gallons.	Water level in feet.	Character of Water.	Remarks.
36,000	-30	Hard	Rock 56 feet from surface.
40,000	+20	Soft........	Rock 60 feet from surface.
72,000	-15	Hard; faint iron taste.	Water at 150 ft. Too hard for boilers.
no water	.. ...	... .	
9,600	....	Good	Rock 4 ft from surface. All water obtained was struck at 300 ft.
60,000	-30	Slightly sulphurous.	Rock 62 feet from surface.
2,400	-11	Very hard....	
72,000	-10	Sulphurous & slightly saline.	Rock 65 ft. from surface. Water at 460 ft., associated with gas.
14,000	-5	Soft, slight iron & sulphur taste..	Water at 750 ft. Rock 68 ft. from surface.
112,800	-24	Saline.........	Rock 83 ft. from surface. Water at 420 ft.
126,000	-36	Hard	Rock 80 ft. from surface.
36,000	-25	Good.	Started on rock surface.
....	0	Sulphurous......	Pocket of gas struck. Rock 60 ft. from surf.
none	....	....	
none	... ...	.. ..	
no water	......	....	Rock 90 ft. from surface.
36,000	-10	Good...... . .	Started on rock.
29,000	-25	Somewhat sulph.	Rock 27 ft. from surface.
40,800	-25	Very hard	Rock at surface.
12,000	0	Good..........	Rock 4 ft. from surface.
12,000	-125	Soft	Rock 5 ft. from surface.
abundant	-10	Good.	Rock 5 ft. from surface.
43,000	-25	Very hard . ..	
7,000 (about)	....	....	
4,800	-9	Rather hard....	Rock 90 ft. from surface.
48,000 (abo't)	-14	Hard.	
15,000	-18	Rather hard....	Water was struck at 700 ft.
24,000	0	Rather hard . .	Rock 10 ft. from surface.
120,000	-60	Good...........	Rock 70 ft. from surface. Used for aerated waters.
28,800	-15	Good..	Rock 37 ft. from surface.
too small to be of use. (8,000	....	.. . .	Rock 62 ft. from surface.
12,000	-30	Soft	Rock 35 ft. from surface. Hard water struck 100 ft. from surface. (See Description.)
too small to be of any val. (4,800)	... .	....	Rock 26 ft. from surface.
48,000	....	Good..........	Rock 22 ft. from surface.
8,400	-30	Good......... .	Rock 40 ft. from surface.
abundant	0	. ...	
10,000	-13	Soft & slightly sulphurous....	Rock 31 ft. from surface.
10,000	-25	Soft & slightly sulphurous.. .	
6,000	-25	Good	Rock 100 ft. from surface.
abundant	......	Pure.........	Rock 75 ft. from surface.
4,000 to 5,000	+6	Soft & slightly sulphurous....	Rock 50 ft. from surface.
5,000	÷10	Saline & sulphur.	Rock 90 ft. from surface. Good water at 450 ft.; sulphurous water at 1190 ft.
72,000	rises to surface	Hard	Rock 57 ft. from surface. Most of the water obtained at 960 ft. None found lower.

WELLS YIELDING POTABLE WATERS.

Wells yielding Potable waters.

1.—R. B. Angus, Esq.—St. Anne de Bellevue.

This well is 222 feet deep. It has a diameter of 4½ inches and yields 48 000 gallons a day, the water rising to within 12 feet of the surface. The water is said to be of good quality.

2.—Messrs Armstrong and Cook—Cadastral No. 140 Subdivision lot 293 Montreal West.

In boring this well water was struck at 350 feet, the flow increasing in quantity with depth. At 500 feet boring operations were discontinued.

Fifty feet of clays and gravels were first penetrated then 25 feet of a shaly rock possibly an outlier of the Utica. The remainder is a limestone of uniform hardness, and which gave sufficient water to keep the drill working easily.

In November 1893, the water was 50 feet below the surface after having been pumped from a depth of 100 feet for 10 hours. In December 1894, the water stood at the 100 foot level after a rest of 6 hours, the pump then being 350 feet from the surface. The water is of good quality, with "traces of iron and sulphur," 10,000 gallons per diem have been pumped. (*See figure 9*).

Messrs. Belding, Paul & Co's well.

3.—Messrs Belding, Paul and Company—On the canal near the Seigneur Street Bridge.

The well is 548 feet deep. It is 6 inches in diameter and yields 91,000 gallons per diem. The water rises to within 10 feet of the surface and is hard. The rock was encountered 64 feet from the surface.

The following are the results of an analysis of the water which was made for the company in February 1903 :

	Parts per million.	Grains per Imp. gallon.
Calcium Carbonate	47	3.29
Magnesium "	90	6.30
Sodium "	35	2.45
" Sulphate	17	1.19
" Phosphate	17	1.19
" Chloride	90	6.30
Silica	10	.70
Organic Matter	80	5.60
	386	27.02

4.—The Bushnell Oil Company—Ville St. Louis.

The well is 305 feet deep. It is in the solid rock and the diameter is 4 inches. The water level is from 20 to 30 feet below the surface and is lowered somewhat on pumping. The water is rather hard, slightly sulphurous, and holds a small amount of suspended clayey material. One thousand gallons are pumped daily but the maximum capacity is much greater, (*See figure 8*).

5. C. S. Campbell Esq , Dorval.

This well is 480 feet deep and yields 500 gallons of water per hour. The hole is $4\frac{3}{4}$ inches in diameter. The water is of good quality and rises to within twenty feet of the surface.

6.—The Canadian Brewing Co., 218 Delorimier avenue, Cadastral number Lot 502 St. Mary's ward. The Canadian Brewery Company's well.

In boring this well, water was struck at a depth of 580 feet. Before rock was reached the drill went through 50 feet of drift, 35 feet of which was "hard-pan."

The water level is 28 feet below the surface. Present requirements only necessitate the pumping of 5,000 gallons per diem, although the tested capacity is at least 24,000 gallons.

The following partial analysis of the water was made by Mr. Baker-Edwards on Oct. 20. 1890. The results are stated in grains per Imperial gallon :

Sodium Bicarbonate	38.00
Sulphur as H_2S or sulphides—	not determined.
Sulphur as SO_4	3.36
Chlorine as NaCl	2.705
Nitrogen as nitrates	0.004
Nitrogen as nitrites	none
Free and Saline Ammonia	0.0025
Albumenoid Ammonia	0.0033
Organic Carbon	none
Hardness	4.2° (Clarke's)

7 and 8.—The Canada Malting Company, St. Henri, Lot 104781, near Lachine canal.

Two wells were sunk on this property a short distance from one another. The first of these is 6 inches in diameter down to a depth of 36 feet, the diameter being then reduced to $4\frac{3}{4}$ inches. In it water

was obtained at a depth of 300 feet and rose to within six feet of the surface, the well yielding 500 gallons per hour. The water is stated to be of good quality but has not as yet been analyzed. The solid rock was reached 32 feet from the surface. After striking water at a depth of 300 feet, the boring was continued to a depth of 678 feet, without any appraciable increase in the quantity of water being observed.

The second well was sunk to a depth of 506 feet and yields 700 gallons per hour. The rock was reached at a distance of 18 feet from the surface and the water, which was of good quality, rose to within thirty feet of the surface.

9.—The Canada Malting Company—C.P.R. property, "Abattoir Site," near St. Henri.

In this well, highly saline water was struck at 350 feet and rose to within ten feet of the surface. The well yielded 750 gallons per hour. Boring was then continued to a depth of 1281 feet, when, no additional supply of water being obtained, operations were discontinued. The hole is $4\frac{3}{4}$ inches in diameter and the rock was reached at a depth of 31 feet from the surface.

The Canada Sugar Refining Company's well.

10.—Canada Sugar Refining Company—150 Montmorency street. This well is 312 feet deep and yields 5,000 gallons an hour. The water rises to within 18 feet of the surface, and is of good quality. The drift here is very thick, the solid rock lying 70 feet below the surface.

The following is an analysis of the water by the chemist of the company, the results being given in grains to the Imperial gallon:

Mineral solids	10.78
Organic do	4.57
	15·35

The mineral solids are as follows:—

Calcium Bicarbonate	4.521
Magnesium do	160
Sodium do	1.330
do Sulphate	1.049
do Chloride	3.720
	10.780

Total Hardness	12.40
Temporary Hardness	1.60
Permanent do	10.80

11 and 12.—Canadian Pacific Railway Work Shops—Hochelaga. The Canadian Pacific Railway Company's well at Hochelaga.

Two wells were sunk on this property, the first to a depth of 539 feet and the second to a depth of 557 feet. The former yields 10,000 gallons an hour, the water rising to within 6 feet of the surface. The second yields 5,000 gallons an hour, the water rising to within 8 feet of the surface. Both wells start with a diameter of 8 inches, which is subsequently reduced to 6 inches The rock is 12 and 13 feet from the surface respectively in the case of the two wells. The water is said to be of excellent quality,

The water from one of these wells collected on February 6, 1903, shortly after the wells were bored, was analysed by Mr. Milton L. Hersey with the following results, stated in grains per Imperial gallon :

Calcium Carbonate	·43
do Bicarbonate	·00
Magnesium Carbonate	·31
Sodium Carbonate	18·00
do Bicarbonate	·00
do Sulphate	·00
do Chloride	8·20
Potassium Chloride	·00
Calcium Chloride	·00
Silica	1·17
Loss on ignition	·00
	3·67
Total solids	31·78

14.—Convent of the Sisters of the Precious Blood—Notre-Dame de Grâce.

This well was sunk to a depth of 296 feet. Water was obtained. the well yielding 1,500 gallons an hour. The water rose to within 20 feet of the surface and is said to be of good quality. The solid rock was reached at 42 feet from the surface.

15.—M. Cousineau, Esq.—Lot 251, St. Laurent.

This well is interesting in that it is one of the few flowing ones of the district, the water rising to a height of 7 feet above the surface

of the ground. The well is 128 feet deep, 40 feet in clay, and 88 feet in limestone; the water is pure and of medium hardness. (*See figure 9.*)

Dr. Craik's well.

16.—Dr. Robert Craik—Lot 192 Petite Côte.

In boring of this well, water was struck first at 250 feet, but not in sufficient quantity to keep the drill wet. At 305 feet however additional water was obtained which rose to within 10 feet of the surface.

The water-bearing stratum is shaly in character and the water was at first impure and sulphurous, but these qualities disappeared on continued pumping giving a pure, soft water. No analysis was made beyond a few qualitative tests which confirmed the excellent quality of the water

In order to test the capacity of the well an engine was used which pumped 5,000 gallons per hour without lowering the water level more than 20 feet below the normal position. A windmill with a six inch stroke is now used; the pump is down 80 feet, while the piping (4 inch), continues 30 feet below the pump. (*See figure 10.*)

17.—Mr. Curran's farm.

The well is situated about half way between Montreal and Back river, about one mile east of the Hotel. It was sunk to a depth of 260 feet and yields 1,000 gallons an hour. The water rises to within 6 feet of the surface. The hole is 6 inches in diameter, and the solid rock was met with 16 feet from the surface.

The Thomas Davidson Manufacturing Co's well.

18.—The Thomas Davidson Manufacturing Company—187 Delisle street, Ste. Cunégonde.

Water was obtained at a depth of 150 feet, the hole having a diameter of 6 inches. The well is pumped every day at the rate of 50 gallons per minute without exhausting the supply of water. The solid rock was reached at a depth of 50 feet from the surface. An examination of the water has been made by Mr. Milton L. Hersey with the following results :—

" Total solids—600 parts per million (42 grains to the gallon).

Observations on Ignition—No charring whatever.

Residue—Alkaline, on account of small amount of bicarbonate of soda naturally present in the water.

Chlorine—30·4 parts per million (2·13 grains to the gallon).

Oxygen consumed—·155 parts per million.

The water although hard is entirely satisfactory for drinking purposes."

21.—The Dominion Wadding Company—Corner of William & Vinet streets, Ste. Cunégonde. The Dominion Wadding Company's well.

This well is within 400 feet of the Lachine canal. Water was struck in 'a hard rock crevice' at a depth of 160 feet from the surface and the boring was continued for an additional 15 feet, when the work was stopped as a sufficient supply of water had been obtained. The hole is 6 inches in diameter and the water rose to within eight feet of the surface. The boring first passed through Drift containing "boulders," rock being reached at a depth of 90 feet. An abundant supply of good water is obtained, which is used in bleaching cotton.

22-25.—Messrs. William Dow and Co.—186-188 Colborne street. William Dow & Co's well.

Four wells were sunk on this property with very different results. They were all 4¾ inches in diameter.

The first was sunk to a depth of 360 feet and yielded 24,000 gallons a day of water which is stated to be pure and it rises to within 50 feet of the surface.

The second was bored to a depth of 420 feet, but the amount of water obtained was too small to make the well of any value. It, however, rose to within 40 feet of the surface.

The third well was bored to a depth of 430 feet, that is, to practically, the same depth as the last, but yields 60,000 gallons per diem, the water being slightly sulphurous and rising to within 30 feet of the surface.

The fourth well which was put down on this property lies toward the corner of Inspector street and is 830 feet deep. It is practically dry. The firm however find that it can more economically employ water obtained from the City Service and they have consequently abandoned these borings. (*See figure 7.*)

26.—Alexander Drummond, Esq.—Petite Côte.

This well is 500 feet deep and yields 350 gallons an hour, the water rising to within 50 feet of the surface. The rock lies five feet below the surface.

27.—Sir George A. Drummond—Beaconsfield. Sir George A. Drummond's well.

In boring this well, the drill first passed through 10 feet of drift, followed by 415 feet of limestone. At 425, water was obtained which

rose to within 10 feet of the surface. It is abundant but hard. A partial log of the borings, from 215 to 360 feet was preserved, and these have been examined with the following results :

From 215 to 320 feet the rock is a dark gray semi-crystalline limestone, somewhat impure and bituminous.

At 325 feet the rock is a light-gray dolomitic limestone which is followed at 340 feet by a light gray highly siliceous bed with practically no carbonates.

The rock at 350 feet is a light-gray dolomitic limestone which is succeeded at 360 feet by a dark gray bituminous limestone.

From this examination it is evident that this well at the 360-foot level has not passed out of the Chazy formation, there being no beds comparable to the Calciferous sand-rock which underlies the Chazy.

The well yields 1,500 gallons per hour. (*See figure 9.*)

28.—J. N. Drummond, Esq.—Lot 199, Petite Côte.

This well was sunk to the depth of 223 feet in the limestone. At the 200 foot level a bed of very hard rock was encountered, beneath which was the water-bearing stratum or band. This had a honeycombed character, representing either a bed of impure limestone rendered porous by the removal of the soluble portion of the rock, or, possibly, a shattered zone filled by a friction breccia. The water rises to within twenty five or thirty feet of the surface, and continued pumping fails to lower it below that level. The water is clear and soft with a slight sulphurous taste (*See* No. 84 and *figure 10.*)

29.—H. A. Ekers, Esq.—Lot 208, Petite Côte.

In this well, water was struck at 325 feet, limestone being the only rock encountered. The water is of a medium hardness and maintains a constant level at 33 feet below the surface. The well yields 600 gallons per hour. (*See figure 10.*)

Well at Eker's brewery.

30.—Ekers' Brewery—409 St. Lawrence street.

This well is 600 feet deep, the first 70 feet being in boulder clay or "hardpan". The water rises to within ten feet of the surface, but on pumping the level is lowered to forty feet. Continued pumping fails to lower it furthur. The well has yielded as much as 25,000 gallons in 24 hours, but its maximum capacity is unknown. A partial analysis of the water, by Dr. Ruttan of McGill University, made on a sample collected on May 25, 1892, gave the following results :—

Total solids	392 parts per million.
	(=27·44 grs. per Imp gall.)
Ash, after ignition	234 parts per million.
Organic and volatile	158 " "
Chlorine	40 " "
Nitrogen, as free and saline ammonia	0·057 parts per million.
Albuminoid ammonia	0·066 "
Nitrates	0·799 "

(*See figure 7.*)

31 and 32.—Excelsior Woollen Mills—967 Ontario street.

Three wells were sunk on this property within a distance of about 200 feet from one another. The results obtained, however, in the three cases, were very different. Wells at Excelsior Woollen Mills

The first well was sunk to a depth of 300 feet and yielded practically no water. The second well was sunk to a depth of 812 feet, 60 feet of "hard pan" being penetrated before the limestone was reached. Water was first obtained at about 600 feet, but the boring was continued to a further depth of 212 feet in the hope of obtaining a larger quantity. The water is pure and free from sulphur and is pumped from an 80-foot level. The maximum quantity which the well yields, however, is only about 5,000 gallons a day. In the morning, when the pump is started, the water level is 100 feet below the surface, but during the pumping it is gradually lowered to 180 feet, at which it remains constant. The diameter of this hole is 6 inches in the drift, after which it is reduced to 4 inches in diameter, the hole being lined to a depth of 400 feet. Samples of the borings from this well were obtained down to the 340-foot level, the rock on examination proving to belong to the Trenton limestone. Before the heavy earthquake which was experienced in the year 1897, the flow of this well was about double that which it has at present.

The third well was sunk at a depth of 754 feet. Some water was struck at 500 feet and a further supply was obtained at 740 feet. The well now yields 3,600 gallons an hour, or about 86,000 gallons a day. In this well the water rises to within 20 feet of the surface. The hole has a diameter of 10 inches at the surface, after which it decreases to 6 inches. The rock is 35 feet from the surface.

These wells are interesting as showing the great variations encountered within a very limited area, not only in yield of water but also in the height to which the water rises, as well as in the thickness of the drift covering. Mr. William Bell, who drilled the holes, states that

there was distinct evidence of the existence of fissures and crevices in the limestone through which these borings passed. (*See figure 7.*)

The Fenlin Leather Company's well.

34.—The Fenlin Leather Company—141 Frontenac street.

This well is 102½ feet deep and might be classed as a dry well, the amount of water obtained (4,800 gallons in 24 hours) being too small to warrant the well being pumped. The rock lies 60 feet from the surface.

35.—M. Gallbert, Esq., 959 St. Catherine street.

This well is 154 feet deep, of which the upper 56 feet is in Drift. The water rises to within five or six feet from the surface, and the amount obtained daily (not the maximum capacity) is 25,000 gallons. The diameter of the bore is 4 inches.

A partial analysis of the water was made by Mr. Milton Hersey, M.A.Sc., and gave the following results, stated in grains per Imperial gallon:

Bicarbonates of Sodium, Magnesium and Lime, and Sodium Sulphate	52·20
Chlorides of Sodium and Potassium	6·25
Silica	1·65
Oxides of Iron and Alumina	trace
Total solids per Imperial gallon	60·10

The water has a distinct alkaline reaction, a slight mineral taste and was somewhat turbid from suspended clayey matter. The temperature is constant at 51° F. throughout the year. (*See figure 7.*)

36.—H. Gatehouse, Esq.—808-810, Dorchester street, Montreal.

The well is 750 feet deep and has a capacity of 20,000 gallons of water per diem (24 hours). The water is of good quality and rises to within thirty feet of the surface. The solid rock was reached at a depth of 46 feet from the surface.

37.—The Globe Wooller Mills Company—219, DeLorimier avenue, (Cadastral No. 1,492) St. Mary's Ward.

The well is 410 feet deep, 35 feet in the boulder clay and the remainder in a limestone of uniform hardness. The water rises to within ten feet of the surface and 2,800 gallons are pumped per hour. A chemical examination made by Prof. J. T. Donald, on Nov. 13, 1890, gave the following results, the figures being grains per Imperial gallon :—

'Mineral matter, consisting principally of Calcium Sulphate, with a small amount of Magnesium Sulphate, 42·63. The sulphates render the water hard, but, apart from these, it contains nothing to render it unsuited for use in dyeing.' (*See figure 7.*)

38 and 39.—The Gould Cold Storage Company—corner Grey Nun and William streets. Two wells have been put down on this property. The first of these was sunk to a depth of 700 feet, at which level the drill was lost, having become jammed in a crevice in the rock. It was found impossible to recover it and operations were not resumed. The well, therefore, was abandoned, no water having being obtained. Gould Cold Storage Company's wells.

In the second well, water was struck at 360 feet, a yield of 10,000 gallons per diem being obtained. The boring was then continued to a depth of 1,301 feet in the hope of securing an additional supply, but without success. The water is said to be pure and it rises to within 40 feet of the surface. The drift covering here is heavy, being 73 feet thick.

40. A. Goyer, Esq.—Frontenac Cadastral No. 1,697, Hochelaga ward.

In boring this well, water was obtained at a depth of 375 feet, the upper 30 feet being through drift. The water is soft. It rises to within 10 feet of the surface. The maximum capacity of the well is about 9,000 gallons per day. (*See figure 8.*)

41. F. Goyer, Esq.—Côte de Neige village.

This well is 250 feet deep, limestone being struck about 25 feet below the surface. The water which is very hard, rises to within 10 feet of the surface. The maximum capacity of the well is not known, but at present from 8,000 to 9,000 gallons are pumped daily.

42. M. Grosboyau, Esq.—1,675 Papineau avenue.

Cadastral No. 161 DeLorimier municipality. This well is 350 feet deep and is wholly in limestone. The water which is soft rises to within 12 feet of the surface. (*See figure 8.*)

45. A. Hobbs, Esq.—Outremont.—Near Canadian Pacific Railway Company's Round House.

This well is 240 feet deep and has a capacity of 48,000 gallons in 24 hours. The water is of good quality and rises to the surface. The hole is six inches in diameter and the rock was met with five feet below the surface.

46. Edward Hughes, Esq.—Lot 487 Côte St. Michel

The well is 75 feet deep, wholly in limestone. The water level is 20 feet below the surface. The water is soft and can be obtained in considerable quantity.

Messrs. Laing & Sons' well.

47. Messrs Laing & Sons. Corner of St. Catherine and Parthenais streets.

The well has a depth of 325 feet, of which the upper 56 feet is in the boulder clay, and the lower 269 feet in limestone.

The water rises to within 30 feet of the surface, and the well is fitted with a pump having a 36 inch stroke which delivers a regular supply at the rate of 36,000 gallons per day.

In 1891, a few weeks after the well had been completed, the water was examined by Prof. J. T. Donald, and the following is the result of a partial analysis, stated in grains per Imperial gallon:—

*Calcium Carbonate	14.32
Alkaline Carbonates with a little Silica	5.31
Sodium Chloride	9.38
Calcium Sulphate	12.65
Suspended matter	2.04
Total	43.70

The suspended matter shown in the analysis caused a turbidity which continued even after the well had been pumped for several weeks. Later on, however, this disappeared and a perfectly clear water was obtained. For comparison of this water with that of the Laurentian baths, see page 47.

Well at the Laurentian Baths.

48. The Laurentian Baths, Messrs. Robert White and Company—208 Craig street.

The well is 285 feet deep, of which the upper 60 feet is in drift—clays and gravels—and the lower 225 feet in limestone. Water was struck at 270 feet. The water rose in a pipe to a height of 20 feet above the surface of the ground, and flowed at the rate of 10,000 gallons in 24 hours. At times, however, the pressure has been found to vary somewhat. On one occasion shortly after the boring was completed the water level at 6 p. m. barely reached the surface, but during the night the water overflowed the 20-foot pipe and flooded the building. The well is now pumped and yields 40,000 gallons per day.

*With a little magnesium carbonate.

Four analyses, showing the composition of the water at intervals during a period of twelve years, have been made by Prof. J. T. Donald, and are given below, in grains per Imperial gallon.

Constituents.	October 28, 1891.	August 26, 1892.	March 11, [illegible]	January, [illegible]
Calcium Bicarbonate	Heavy trace		1.[illegible]	1.78
Magnesium Bicarbonate			1.72	1.13
Sodium Bicarbonate	27.35*	26.74*	32.37	22.37
Sodium Sulphate	6.85	[illegible]	9.00	9.44
Calcium Sulphate		3.47		
Magnesium Sulphate		1.02		
Sodium Chloride	2.32	9.50	[illegible]	[illegible]
Potassium Chloride		.	.77	.11
Silica			.43	.49
Total	36.42	41.72	[illegible]	41.62

An interesting point in connection with this water is the very small amount of the carbonates of lime and magnesia, and the large proportion of the alkaline carbonates present. This is of especial interest in view of the fact that in the water from the well of Messrs. Laing & Co., a short distance away, the relative proportion of these constituents is reversed.† (See analysis, p. 46). No samples of the borings were preserved with the exception of a small fragment brought up from the level at which the water was struck. This on examination proved not to be limestone but a soft black shaly rock traversed by a few veinlets of a light coloured impure dolomite. Before the blowpipe both the rock and veins fuse on the edges to a blebby glass. This shale is evidently part of one of the beds which occur interstratified with the Trenton limestone. To the passage of the water through this shale instead of through the limestone may be due the presence of lime in so small an amount.

Another analysis, by Mr. Milton Hersey, M. A. Sc., gave the following results in grains per Imperial gallon :—

* Alkaline Carbonates with a little Silica.

† The Waters of Two Artesian Wells in the Eastern Part of the City of Montreal. By J. T. Donald. Can. Rec. of Science, Vol. V, No. 2, April, 1892.

Chlorides of Sodium and Potassium	6·17
Sulphates of Magnesium, Calcium and Sodium	45·37
Silica	1·65
Total	53·19

It is probable that in this analysis the large proportion of sulphates shown is due to the calcium, magnesium and sodium having been calculated as sulphates, although they really exist in part at least in other forms.

The earthquake which occurred in the autumn of 1893 produced a very perceptible turbidity in the water, which lasted for about a day and a half.

Part of the water pumped is drawn off immediately and used in the manufacture of soda water and ginger ale, or used for drinking purposes, but the greater part is used to supply the large and well equipped swimming bath, Turkish baths, etc., on the premises. This well, considering the short distance which it was necessary to bore, and the character and the volume of the water obtained, must be regarded as one of the most successful borings which has yet been made on the Island of Montreal. *(See figure 7)*.

The Laurie Engine Company's well.

49.—The Laurie Engine Company—1020, St. Catherine street.

Water was first struck after boring through 65 feet of drift and 85 feet of limestone, but boring was continued to a depth of 300 feet. The water is clear and sparkling with a faint chalybeate taste, and rises to within fifteen feet of the surface. It is too hard to be used in boilers. 27,000 gallons are pumped daily. *(See figure 7 and page 63)*.

51.—The Longue Pointe Asylum—Longue Pointe.

Water was obtained at a depth of 300 feet from the surface, the well yielding nearly 9,600 gallons per diem. The boring was then continued to a depth of 2,000 feet, but no further supplies of water were secured. The rock here is about 4 feet from the surface.

An interesting fact in connection with this well is that about half a mile to the north of the spot where the boring was located, a spring issues from the country rock with a flow of 2,500 gallons an hour, or 60,000 gallons per diem, the water rising through a rather large fissure which here reaches the surface; while along the line of the boring, although 2,000 feet of strata are traversed, only a single small water-bearing crevice was encountered.

53.—A. Martin, Esq.—Lot 1010, Parish of Lachine.

In sinking this well, gas and water were struck at 460 feet below the surface. The gas burned for 12 hours, when the supply became exhausted. Boring was then continued to 740 feet without obtaining any greater volume of water. The drift consists mainly of "hardpan" and is 65 feet thick. Between the hardpan and the limestone a thin layer of quicksand was encountered. The water rises to within eleven feet of the surface. It is of a good quality but very hard. If it is covered for some time, a faint sulphurous odour is detected. The supply is limited, the well yielding only about 100 gallons per hour. The diameter of the hole is 6 inches.

55.—Mrs. J. McIntosh—Lot 429, Côte St. Michel.

The well is 120 feet deep and the water rises to within four or five feet of the surface. It is soft with slight chalybeate and sulphurous taste. The latter, however, disappears on allowing the water to stand for some time. A steam pump is used to raise the water, the pipe being an inch in diameter.

57.—Montreal Brewing Company—1334 Notre Dame street (Lot 19 St. James Ward.) The Montreal Brewing Company's well.

This well is 502 feet deep, the first 80 feet being in "hardpan." Water was first struck at 497 feet, and from the working of the drill it would seem that the water rose from a fissure about eight inches wide. The water level is 36 feet below the surface. The maximum capacity of the well is not known, but it has yielded 126,000 gallons in 24 hours. The bore is 4⅝ inches in diameter.

An analysis of the water taken from the well on April 9, 1895, was made by Prof. J. T. Donald. The results are as follows, expressed in grains per Imperial gallon :—

Calcium Carbonate	15·03
Magnesium Carbonate	8·19
Ferrous Carbonate	1·43
Sodium Carbonate	3·75
Sodium Chloride	11·51
Calcium Sulphate	25·80
Silica	1·31
Total	67·02

Free and loosely combined Carbon Dioxide..........	17·35
Hardness....................................	21·50

(*See figure 7.*)

58.—Mount Royal Cemetery, near the Crematory.

This well is 354 feet deep and has a capacity of 36,000 gallons in 24 hours. The hole is 4¾ inches in diameter and the water, which is of good quality, rises to within twenty-five feet of the surface. The boring starts in solid rock.

The Montreal Cold Storage Company's well.

59.—The Montreal Cold Storage Company—604 610 St. Paul street.

This well is 1020 feet deep, the first 60 feet being in drift. Water was obtained which rose to the surface, but the flow was irregular owing to the escape of gas. A pump arranged to take water from the 400 foot level was then fitted in the well. The first water obtained was dark in colour, owing to the distribution through it of minute flecks of sulphide of iron. At the time the well was visited the water was running alternately darker and clearer at intervals of a few minutes, giving off gas which when ignited burned with a bright flame. After pumping for a time the pressure of the gas became so great that the pump rod could not be forced down, and operations had to be discontinued until the gas escaped. If the well were fitted with a pump properly constructed for the purpose, this difficulty arising from the presence of the gas would disappear. It is quite probable that the sulphide of iron is produced by the action of the sulphuretted water upon the pump rods and iron casing, and that by continuous pumping its amount would greatly decrease. (*See figure 7.*)

63.—The Montreal Hunt Club—Outremont.

This well was started on rock at surface and was drilled to a depth of 226 feet. The boring is six inches in diameter and yields 36,000 gallons of good water in 24 hours; the water rises, within ten feet of its surface.

65.—Montreal Milling Company—Park Avenue, Outremont.

This well is 345 feet deep, and is wholly in limestone. Water was struck at 337 feet. but boring was continued 8 feet farther, the last foot being in a rock with a honeycombed or porous structure.

The water level is 25 feet below the surface, and this was not lowered after pumping 1,700 gallons per hour for 144 hours. The water is saline and is unfit for use.

The diameter of the well is 5 inches. I. boring it was found that the rock varied somewhat in hardness, the progress of the drill varying from 5 feet to 20 feet in 12 hours (*See figure .*)

66.—Mount Royal Park.

This well was sunk on the Mountain opposite the water tank. It is 66 feet deep, 4 feet being in drift and 62 feet in the Essexite rock which composes the greater part of the Mountain. The diameter of the hole is 4 inches. The water is pure and abundant ; in the spring time it rises to the surface but does not overflow.

67.—Montreal Weaving Company—595 Clarke street, Ville St. Louis.

The Montreal Weaving Company's well.

This well is 420 feet deep and with the exception of 5 feet of drift it is wholly in the limestone. At the 200 feet level a bed of very hard rock was struck through which the drill went very slowly. This bed was probably, an intercalated still of igneous rock. The water rises to within 125 feet of the surface It is pure and soft. 800 gallons a day are now pumped, but the well has a capacity of 12,000 in 24 hours (*See figure 8.*)

68.—G. Nantel, Esq.—Terra Nova, Côte des Neiges.

This well was bored to the depth ot 500 feet, of which the first five feet were in drift and the rest in limestone. The water is very pure and abundant. It does not rise to the surface. (*See figure 9.*)

69.—Outremont Milling Company—Outremont.

The well has a capacity of 43,000 gallons in 24 hours. This boring is 4 inches in diameter and has been carried to a depth of 335 feet. The water is very hard and rises to within 25 feet of the surface. (*See figure 8.*)

70.—Judge Pagnuelo—Pagnuelo avenue, Outremont.

This well has been sunk in limestone to a depth of 700 feet. Only a comparatively small amount of water being obtained work was discontinued at that level. The well is stated to have a capacity of about 7,000 gallons in 24 hours.

71.—Mrs. Quiggley—South end of Lot 9, Longue Pointe.

The well is 100 feet deep, 90 feet being in drift and 10 feet in limestone. It yields 200 gallons per hour. The water is of medium hardness, and rises to within nine feet of the surface. (*See figure 8.*)

72.—A. Ramsay, Esq.—Inspector street, (Cadastral No. 1758 St. Antoine ward).

Water was struck at 800 feet and rose to within fourteen feet of the surface. The Troy Steam Laundry attempted to use it for washing but it was found to be too hard. The well has a capacity of about 2,000 gallons per hour.

73.—A. Ramsay, Esq.—Cadastral No. 282, Lot 4, Westmount.

This well was sunk through solid rock to a depth of 880 feet, water being first struck at 700 feet. The water rises to within eighteen feet of the surface; it is of good quality although somewhat harder than that of the St. Lawrence river, but it is quite suitable for all domestic purposes. The capacity of the well is about 15,000 gallons per diem.

74.—M. Phéaume, Esq.—Foundry, Intersection of Canadian Pacific Railway track and Carrière street, Ville St. Louis.

In boring this well, 10 feet of sandy drift and 290 feet of limestone were passed through before water was obtained. The water is rather hard; it rises to the surface but does not overflow. At the time of inquiry only 100 gallons were being used daily, but the capacity of the well is about 24,000 gallons in 24 hours. *(See figure 8.)*

Messrs. Rowan Brothers' well.

75.—Messrs. Rowan Brothers, Ginger Ale Manufacturers—618, Beaudry street.

This boring has a depth of 600 feet, of which the first 70 feet was through boulder clay and gravels. The water rises to within sixty feet of the surface and the well has a tested capacity of 5,000 gallons per hour. The water is pure and the amount used daily in the manufacture of ginger ale, soda water, etc., varies from 1,500 to 2,000 gallons. This is sometimes referred to as the Mooney well. *(See figure 7).*

76.—The Royal Golf Club—Dixie.

This well is 450 feet deep and yields 28,800 gallons per day, the water rising to within fifteen feet of the surface. The water is stated to be of good quality. The drift covering here is 37 feet thick.

77.—The Salvador Brewing Company, (Reinhardt's brewery)—617 St. Paul street.

This hole is 550 feet deep and has a diameter of 4½ inches. The rock was met with 62 feet from the surface. The well gives too little water to be of much value, and like other wells of this yield might be

classed as a dry well. The actual yield is from 300 to 400 gallons an hour, or about 8,000 gallons per diem.

78.—The Sault au Recollet College—Black river.

Well at Sault au Recollet College.

In boring this well 35 feet of drift was first traversed when the solid rock was reached. The boring was continued in this, the hole being 6 inches in diameter, and at a depth of 100 feet from the surface water was struck which could be pumped at the rate of 2,000 gallons per hour. This water, however was hard, and it was therefore decided to continue boring in the hope of obtaining a supply of better water. At a depth of 490 feet from the surface, a second water-bearing crevice or band was struck, and in this the water was soft. The upper hard water was accordingly cut off from the hole, and the soft water derived from the lower source alone was used. This rises to within thirty feet of the surface and when pumped yields 500 gallons per hour.

79.—The Shawinigan Water and Power Company—Maisonneuve.

This hole is 1,017 feet deep, but yields only 4,800 gallons a day, the quantity being too small to be of value. Rock lies 60 feet from the surface.

80.—Convent of the Sisters of Providence—Notre Dame de Grâce.

The drilling was carried to a depth of 320 feet. The hole is 4½ inches in diameter. The rock was encountered 22 feet from the surface. The well yields 48,000 gallons per diem and the water is said to be pure.

81.—The Stanley Dry Plate Company—613 Lagauchetière street.

The well is 1,300 feet deep and yields about 8,400 gallons of good water in 24 hours. This hole is 4¾ inches in diameter, and the water rises to within 30 feet of the surface. The drift is here 40 feet thick. (*See figure 7.*)

82.—St. Laurent Convent—St. Laurent.

In this well water was obtained at 250 feet. The water rose to the surface. It is hard, with a slight sulphurous taste and the supply is abundant. (*See figure 9.*)

83.—St. Laurent College,—St. Laurent.

Wells at St. Laurent College and convent.

The well is 487 feet deep. In boring, the drill first passed through 31 feet of "hardpan" and then through 456 feet of limestone. The normal water level is 13 feet below the surface. On pumping, this is lowered to 27 feet, at which it remains until pumping is suspended.

The water is pure and soft. A rough analysis at the college gave small amounts of lime and magnesia. The capacity of the well is not known, but it easily yields 10,000 gallons a day. (*See figure 9.*)

84.—Mr. Stewart, Lot 195, Petite Côte.

This well is similar to No. 28 in every particular and doubtless has its source in the same water-bearing zone or bed. (*See page 42 and figure 10.*)

85.—T. A. Trenholme, Esq.—Cadastral No. 141, Côte St. Pierre.

In this well water was obtained at the depth of 185 feet, the drill passing through 100 feet of drift and 85 feet of limestone. The water rises to within twenty-five feet of the surface; it is very pure and 6,000 gallons are pumped daily. (*See figure 9.*)

86.—T. A. Trenholme, Esq., Thorne Hill, Côte St. Pierre.

This well is 175 feet deep, 75 feet of drift and 100 feet of limestone being penetrated. The water is pure and abundant.

Turkish bath well.

87.—Turkish Bath Hotel, 140 St. Monique street.

This well is 1550 feet deep, of which the first 50 feet is in "hardpan." Water was struck which rose 6 feet above the surface. Although a flowing well, it is necessary to pump it in order to obtain the amount of water required. The capacity, without lowering the water level much below the surface, is between 4,000 and 5,000 gallons per day. The water is soft and slightly sulphurous.

Specimens of the drillings from different levels were obtained and these have been examined with the view of ascertaining the character and thickness of the formations penetrated by the boring. The results show that the well is wholly in the limestone series. Here and there, however, igneous rocks have been encountered, which are of the nature of dykes or intercalated sills.

At a depth of 50 feet from the surface Trenton limestone was struck, which formation continued down to about the 525 foot level, when fossils determined by Dr. Ami as referable to the Birdseye formation were found. At 640 feet, fossils of the Chazy were detected. Judging from the scanty evidence obtained from fossil remains, combined with the results of a chemical examination of the rock, it seems that this formation extends downwards to about the 1425th foot level. At this depth magnesian limestones, more or less impure and siliceous, were met with, and these continue down to the 1540th foot level. The last 10

feet consisted of sandstones which represent the more siliceous beds of the Calciferous, to which formation the magnesian limestones presumably belong.

The formations traversed and their thicknesses may be represented in tabular form as follows:

Pleistocene (drift)	50 feet
Trenton and Birdseye Limestone	590 "
Chazy Limestone	785 "
Calciferous Limestone	125 "
Total	1550 feet

The Potsdam sandstone was not reached in this boring and it is probable from the thickness of the Calciferous traversed that the sandstone is considerably below the 1550th foot level. *(See figure 7.)*

88.—The Wire and Cable Compang—Corner Guy and St. James streets. Wire and Cable Company's well.

Water was struck 960 feet from the surface, and sinking was then continued to a depth of 1055 feet in hope of obtaining a larger supply of water, but without success. The water just rises to the surface. The yield of the well was tested by pumping for 14 consecutive hours, at the rate of 3,000 gallons an hour. This resulted in the lowering of the level of the water by 16 feet, which lowering took place when the pumping began, after which time the water level sunk no further. The hole is 6 inches in diameter down to a depth of 40 feet from the surface, below which the diameter is 4¾ inches. The solid rock was met with 57 feet from the surface.

An analysis of the water by Dr. J. T. Donald gave the following results in grains per Imperial gallon:—

Carbonate of Lime	22·09
Carbonate of Magnesia	2·79
Carbonate of Iron	·53
Carbonate of Soda	12·20
Sulphate of Lime	1·24
Chloride of Sodium	1·55
Total solids	40·40

Wells affording Saline Waters or Waters containing Sulphuretted Hydrogen.

Canadian Pacific Railway Company's well at Outremont.

18. Canadian Pacific Railway—Outremont, North End of Cadastral Lot No. 35, Parish of Montreal.

After traversing 25 feet of clay, the drill struck rock and the boring was continued to the depth of 410 feet. The water level is 8 feet below the surface, but on pumping at the rate of 8,000 gallons per hour the level is lowered to 22 feet, 6 inches. The diameter of the hole for the first 300 feet is 5½ inches, and is then reduced to 4 inches.

The water is not pure, being "charged with sulphur and salts" and is unsuitable for use in locomotives. An analysis supplied by the company shows it to have the following composition, in grains per Imperial gallon :

Calcium Carbonate	15·133
Magnesium Carbonate	4.347
Potassium Chloride	1·34
Sodium Silicate (Na_2 Si O_3)	2·56
Sodium Sulphate	3·21
Calcium Sulphate	9·09
Oxides of Iron and Alumina	0·42
Total	36·090

(*See figure 8.*)

Messrs. Dawes & Co's well.

19. Messrs. Dawes & Co.—Lot 202D Lachine.

At a depth of 1,003 feet, water was obtained which rose to within 10 feet of the surface. At first, pumping was carried on daily for 3 or 4 hours at 60 lbs. pressure, through a 2 inch pipe, without lowering the level. The temperature of the water was constant at 48° F. throughout the year. An examination of the water was made by E. B. Kenrick Esq. of Winnipeg with the following results :—

The water was somewhat turbid.

Solids dried at 100° C, 4670 parts per million=326·9 grains per Imperial gallon.

Loss on ignition 1050 parts per million.

Nitrogen as Albuminoid Ammonia	0·06
" as Free and Saline	0·31
" as Nitrates and Nitrites	0·21

Chlorine as Chlorides	640·00
Phosphates	trace.
Oxygen absorbed at 80° F. in 15 minutes	0·336
" " 4 hours	0·744

On ignition, there was no blackening of the total solids 'I am of the opinion that the sample is fairly free from organic impurities, but contains too much saline matter to be a first class water.'

An analysis made by Frank Faulkner, Esq. is as follows :—

Free Ammonia	0.720 parts per million.
Albuminoid Ammonia	0.170 " "

The following results are given in grains per Imperial gallon :

Chlorine	44.80
Nitric Acid	None.
Sulphuric Acid	119.28
Calcium Carbonate	20.58
Lime otherwise combined	51.83
Magnesia	22.36
Soda	Undet.
Saline residue	271.60
Organic and Volatile matter	54.46
Total solid residue	326.06

The following represents according to Mr. Faulkner the most probable composition of the saline residue.

Calcium Carbonate	20.58
Calcium Sulphate	125.84
Magnesium Sulphate	67.86
Sodium Chloride	73.92
Total	288.23

(*See figure 9.*)

20. W. B. Dickson, Esq.—Lot 21 Longue Pointe.

This well is 170 feet deep, 100 feet being in drift and 70 in limestone. The water rises to within 13 feet of the surface. It is impure, saline, and strongly impregnated with sulphuretted hydrogen. The water pumped the first two days was perfectly black, but it gradually became clearer. (*See figure 8.*)

41. Chas. Gurd, Esq.—30-42 Jurors street. Lot 696.

In sinking this well, limestone was struck 18 feet from the surface, and water was first obtained at 440 feet but the supply was very limited, becoming exhausted in 8 hours when pumped through a 2 inch pipe. Boring was then continued to 512 feet and water was struck which rose to the surface and flowed at the rate of 800 gallons in 24 hours. On pumping, however, it will yield 4,000 gallons in the same time, but if forced above that the well is drained below the 360 foot level where the pipe ends, and some hours elapse before it refills. The water is strongly impregnated with sulphuretted hydrogen gas, resembling in this respect the water obtained at Viau's well, Maisonneuve. *(See figure 7.)*

44. Mr. Hampson—Lot 40 Longue Pointe.

This well was sunk in limestone to the depth of 502 feet, when an impure saline water strongly impregnated with sulphuretted hydrogen, was struck. The water is unfit for use.

Well of Messrs. Lowell and Christmas.

52. Messrs Lovell and Christmas—63 William street.

This hole is 612 feet deep and has a diameter of 6 inches. The water is slightly sulphurous and rises to within 30 feet of the surface. The well has a capacity of 60,000 gallons a day, and the firm in 1903 were regularly pumping 43,200 gallons per diem. When pumping, the water level is lowered to 168 feet, below the surface. The rock is met with at a depth of 62 feet. This water was examined by Milton L. Hersey, M. App. Sc. who reports upon it as follows:

'Odor of water.... ....Sulphuretted hydrogen.
Appearance of water.....Turbid, when pumping is stopped.
Temperature of water............................50° F.
Total solid matter on evaporation.....600 parts per million.
Solids volatile on ignition............130 parts per million.
Odor of solids on ignition............................none.
Charring of solids on ignition........................none.
Organic matter (oxygen consumed)...1.35 parts per million.

(This is really not due to organic matter but to the presence of sulphuretted hydrogen and other sulphur compounds).

Chlorine as chlorides.............127.71 parts per million.
Free ammonia...................0,784 parts per million.

(This quantity of free ammonia is more apparent than real on account of the presence of sulphuretted hydrogen).

Albuminoid Ammonia	0.051 parts per million.
Total Ammonia	0.835 parts per million.
Nitrogen as Nitrites	very faint traces
Nitrogen as Nitrates	none.
Gas producing bacteria in phenol-dextrose broth	none whatever.

I consider this water free from objectionable contamination so far as its sanitary properties are concerned.'

54. Messrs. A. S. and W. H. Masterman—208½ Notre Dame street, Cadastral No. 1503 St. Anne's ward. Well of Messrs. A. S. and W. H. Masterman.

In the case of this well rock was struck 68 feet from the surface, and water was obtained at 750 feet. Boring was continued to 800 feet, the last 50 feet being to provide a sink-hole for the sediment. The water level is 10 feet, 10 inches, below the surface, and the supply is stated to be undiminished when pumped at the rate of 3,000 gallons per hour.

An analysis by Dr. G. P. Girdwood is given below, the results being stated in grains per Imperial gallon :

Calcium Carbonate	23.35
Ferrous Carbonate	0.44
Sodium Chloride	15.36
Magnesium Chloride	13.11
Calcium Chloride	26.80
Calcium Sulphate	1.28
Silica	3.08
Total	83.42

Free ammonia	20 parts per million.
Albuminoid ammonia	.11 parts per million.

Some Sulphuretted Hydrogen is also present.

The earthquake of 1897 did not affect this well, but that of 1895 broke the iron casing 40 feet below the surface and necessitated its removal. (*See figure 7.*)

56. Messrs J. H. R. Molson and Brothers—1,006, Notre Dame street. Well of Messrs. J. H. R. Molson and Brothers.

The well is situated on Cadastral No. 28 of St. Mary's ward, being the south corner of Notre Dame and Monarque streets, at what

is known as Molson's Brewery. Water was obtained at adepth of 420 feet. The boring was then continued to a depth of 672 feet without obtaining any increased supply. The water rises to within twenty four feet of the surface, but is lowered by pumping to eighty-three feet, the well yielding 4,700 gallons per hour. The hole is 8½ inches in diameter down to the solid rock, then 6 inches for the next forty-two feet, when it is reduced to a diameter of 4¾ inches. As usual in the wells in this lower part of the city, the drift covering is very thick, here amounting to 83 feet. The temperature of the water is 52° Fah.

The results of an analysis of the water, made for Messrs. J. H. R. Molson & Brothers, are as follows, stated in parts per 100,000 and also in grains per Imperial gallon :—

	Parts per 100,000.	Grains to the gallon.
Calcium Carbonate	11.35	7.95
Magnesium Carbonate	8.83	6.18
Sodium Sulphate	40.77	28.54
Sodium Chloride	22.23	15.56
Sodium Carbonate	16.44	11.51
Potassium Sulphate	3.01	2.11
Silicates of Iron and Alumina	2.13	1.49
Fixed Mineral Salts	104.76	73.34
Total Solid Residue at 127° C.	107.64	75.35
Loss on gentle ignition of residue	2.88	2.02
Free Ammonia	.018	
Albuminoid Ammonia	.005	
Nitrates	Nil.	
Nitrites	Nil.	
Chlorine	13.49	9.44
Phosphates	Trace.	
Iron in Solution	Nil.	
Total Hardness (soap test)		24.40
Temporary Hardness (soap test)		11.60
Permanent do do		12.80

The water has a saline taste, a marshy odour and an opalescent colour. It gives an alkaline reaction with litmus paper. The "biological condition" of the water is stated by the analyst to be "unsatis-

factory", but this fact as well as the saline character of the water is of little consequence, since the firm requires the water merely for cooling purposes. (*See figure 7.*)

64. The Montreal Locomotive and Machine Company—Longue Pointe. Well of Montreal Locomotive and Machine Company.

This well is 514 feet deep and yields 1,200 gallons an hour, the water rising to within 25 feet of the surface and having a strong odour of sulphuretted hydrogen. The solid rock was encountered 27 feet from the surface.

Two analyses of this water were made by Milton L. Hersey, M. App. Sc., the first being of a sample collected on July 23, 1903, being pumped from a depth of 25 feet below the surface, and the second collected on September 14, 1903, being pumped from a depth of 125 feet.

The results of these analyses are as follows in grains per Imperial gallon :—

	July 23, 1903.	Sept. 14, 1903.
Calcium Carbonate	1.39	none.
Magnesium Carbonate	1.57	trace.
Sodium Sulphate	2.52	4.72
" Chloride	1.51	10.39
" Carbonate	29.00	41.86
Silica	.21	.66
Ferric Oxide / Alumina	.50	trace.
Total Solid Matter	36.70	57.63

88. Messrs Viau & Frere—Maisonneuve, Subsection of Lot 5, Longue Pointe. Well of Messrs. Viau & Frere.

This boring was made in the hope of striking natural gas. Bed rock was encountered after the drill had passed through 90 feet of drift. At 450 feet good water was met with which rose to within 10 or 12 feet of the surface. The boring was continued to a depth of 1,190 feet, when water strongly impregnated with sulphuretted hydrogen was struck, which rose to the surface and flowed at the rate of 5,000 gallons in 24 hours.

The final depth reached was 1,500 feet and it is stated that the only rock encountered was limestone.

On the completion of the well a sample of the water was collected. This was analysed in 1890, by Dr. Frank D. Adams. The water when

received for analysis had a faint, yet decided odour of sulphuretted hydrogen, and contained a trifling amount of sediment. The colour of the clear water in a column 2 feet in height was light yellow; the taste mildly saline; the reaction faintly alkaline. The specific gravity at 15.5° C. was 1.00631. The total dissolved matter by direct experiment, dried at 180° C. in 1,000 parts by weight of water was 7.4129.

Analysis of water.

The water contained for 1,000 parts by weight :—

Potassa	0.190
Soda	3.3899
Lithia	undetermined.
Lime	0.836
Strontia	undetermined.
Magnesia	0.1165
Ferrous Oxide	undetermined.
Alumina	trace.
Sulphuric Acid	1.6636
Boracic Acid	undetermined.
Carbonic Acid	0.3819
Phosphoric Acid	undetermined.
Chlorine	2.4623
Iodine	0.000027
Bromine	undetermined.
Silica	0.0135
Organic Matter	undetermined
Total	8.130327
Less Oxygen equivalent to Chlorine	0.5555
	7.574827
Sulphuretted Hydrogen—when received	0.0098

The constituents may be assumed to exist in the water combined as follows: the carbonates being calculated as mono-carbonates, and all the salts being estimated as anydrous.

Calcium Carbonate	0.0855
Magnesium Carbonate	0.2447
Potassium Chloride	0.0301
Sodium Chloride	4.0358
Sodium Sulphate	2.8624

* Geological Survey of Canada. Report of Progress, Vol. IV, 18 R.

Calcium Sulphate	0.0867
Alumina	trace
Silica	0.0135
	7.3587
Carbonic Acid-half combined	0.1658
Carbonic Acid-free	0.0503
	7.5748

These quantities if calculated, for purposes of comparison with the other waters, as grains per Imperial gallon, would be as follows:

Calcium Bicarbonate	8.617
Magnesium Bicarbonate	26.103
Potassium Chloride	2.107
Sodium Chloride	282.506
Sodium Sulphate	200.368
Calcium Sulphate	6.069
Silica	0.945
Alumina	trace
	526.715
Free Carbonic Acid	3.521
Total	530.236

(*See figure 8.*)

DRY WELLS.

33.—The Excelsior Woollen Mills—967 Ontario street. Dry wells.

This well is 300 feet deep.

39.—The Gould Cold Storage Company—20 William street.

This well was sunk to the depth of 500 feet. At that level the drill was lost in a crevice in the rock and, not being recovered, operations were not resumed.

50.—The Laurie Engine Company—1012 St. Catherine Street.

This hole was bored a short distance from the well previously mentioned. (*See page 48.*) It has a depth of 700 feet.

60 and 61.—The Montreal Gas Company—Hochelaga.

Two borings were made, about 600 feet apart, the respective depths being 1850 and 2550 feet. Of the deeper well a set of 20 specimens

was obtained from Mr. W. Bell for examination. They were taken from between the 2200 and 2373 foot levels. Without exception they were found to be fine-grained, impure, siliceous dolomites, associated with thin beds of dolomitic shale. At the 2373rd foot level the limestone was so impure that the chips retained their original forms after boiling in dilute hydrochloric acid.

For purposes of comparison, typical specimens of the rock of the Calciferous from Lachute and Ste. Anne's were examined, as well as some from the Chazy and Trenton formations. It was found that the Calciferous specimens were identical in character with the rock obtained from the boring, and it seems highly probable that the Gas Company's borings terminated in the Calciferous sandrock formation.

At 2,200 feet and 2,325 feet respectively, chips were found which are evidently of igneous origin, one a dark basic mica trap, and the other a much decomposed porphyrite. These two are probably fragments of dykes which are connected with the intrusion of Mount Royal.

62.—Montreal Gas Company—Ottawa street.

After boring through 90 feet of "hardpan" and 960 feet of limestone, operations were discontinued.

There are two other wells which are worthy of mention, although they have not been included in the list given above, because in one case the well is not actually on the Island of Montreal, and in the other case the well was bored at a later date than December 31, 1903, having been completed in the spring of 1904.

The Laprairie Pressed Brick Company—Laprairie.

A boring was made through 1,000 feet of shales, without meeting limestone and without obtaining water. This boring not being actually on the Island of Montreal is not included in the tabulated list.

Côte des Neiges Cemetery—Montreal.

This well is of especial interest on account of the fact that it starts at the surface in the Essexite intrusion of Mount-Royal—which underlies the greater part of this cemetary—and continues down this intrusion to a depth of 486 feet. Whether the Essexite maintains a uniform character throughout this whole distance is not known, but the powdered rock brought up from depths of 482 feet and 485 feet, and a fragment of the rock from a depth of 486 feet have been obtained from Mr. William Bell who drilled the hole and they show

that the well ended as it began in Essexite. Thin sections made from the fragment obtained from the bottom of the well, show that the Essexite there is of medium grain and very basic in character being composed essentially of Pyroxene and Hornblende with accessory Magnetite, Biotite, Apatite and Pyrite. It is possible that a little Olivine is also present. This rock therefore represents the Pyroxenite differentiation facies which is often largely developed at the surface. It closely resembles certain black varieties of the rock found in the cemetary near the contact of the Nepheline Syenite intrusion where this is quarried at Outremont. The rock from 485 and 486 feet contains a certain amount of plagioclase.

The precise level of the spot where this boring was commenced has not as yet been determined, but is probably somewhere about 500 feet above sea level, so that the hole penetrates the mountain down to about the level of the St. Lawrence River.

It yields but little water. Mr. Bell states that he pumped 1,500 gallons when testing it.

CHEMICAL COMPOSITION OF THE WATERS.

Chemical composition of the waters.

Most of the waters, as has been shown, are potable, but some of them are hard, owing to a considerable content of lime or magnesia salts and are therefore unsuitable for use in steam boilers. Others, however, are soft and adapted for such use. Some few, on the other hand, are impregnated with sulphurous compounds or are too saline in character to be of use except for cooling purposes. As has been mentioned, a throughly satisfactory comparative study of the composition of the various waters cannot be made, owing to the fact that those of which analyses exist have been analyzed by different chemists who may have, and in all probability have to a certain extent at least, followed different plans in combining the different acids and bases, the amounts of the several acids and bases actually determined not being stated. The analyses, furthermore, have been made merely for technical purposes and are in most cases incomplete. A comparative examination of them, however, brings out some interesting points.

Six classes of Dr. Hunt.

Dr. Sterry Hunt, many years ago, made a somewhat extended study of the waters of the mineral springs which at many points rise through the unaltered palæozoic strata of the Provinces of Quebec and Ontario * and found that these might be divided into six classes as follows :

*Geology of Canada, p. 531 et seq.

Class I. Saline waters containing sodium chloride with large proportions of calcium and magnesium chlorides, sometimes with sulphates. Calcium and magnesium carbonates are present only in very small quantities or are altogether wanting.

Class II. Saline waters which differ from the first in containing beside sodium, calcium and magnesium chlorides, considerable proportions of calcium and magnesium bicarbonates, the latter carbonate usually preponderating.

Class III. Saline waters which contain beside sodium chloride, a portion of sodium carbonate, with calcium and magnesium bicarbonates.

Class IV. In these waters sodium carbonate preponderates. They contain but a small proportion of sodium chloride, and generally hold a much smaller amount of solid matter than the waters of the previous classes.

Class V. Waters containing a large proportion of free sulphuric acid.

Class VI. Neutral saline waters in which calcium, magnesium and alkaline sulphates predominate, chlorides being present only in small amount.

Classes to which the Montreal waters are referable.

The waters from the deep wells of the Montreal district cannot of course in the majority of cases be classed as mineral waters, being for the most part of potable quality, but those among them which are saline waters can be so classed, and all of them rising from the same great plain as the waters studied by Dr. Hunt might be expected to possess the same general characters in respect of the nature of the dissolved materials, although containing these in lesser amount.

An inspection of the analyses given in this Report will show that there are among them no representatives of Dr. Hunt's classes I and V, while some of the waters do not seem to be referable to any of the classes which he has established but to present intermediate characters.

Class II is represented by Messrs. A. S. & W. S. Masterman's well, although the water is not a very highly saline one.

To Class III is to be referred the water of the well put down by Messrs. Belding, Paul & Co.

Several of the waters are clearly referable to Class IV of Dr. Hunt's series, being characterized by a predominance of sodium carbonate. Of these, the water of the Laurentian Baths, that of the Montreal Locomotive and Machine Company, that of the Canadian Pacific

Railway shops at Hochelaga and of Mr. Galibert's well may be instanced. The water obtained by the Wire and Cable Company belongs to this class, although it contains, in addition to the sodium carbonate, a considerable proportion of calcium carbonate and some magnesium carbonate, thus resembling the water from St. Ours, analyzed by Dr. Hunt.

Class VI is represented by the water obtained by Messrs. Dawes & Co., at Lachine.

The waters from the well owned by Messrs. Viau & Frère and that of Messrs. J. H. R. Molson & Brothers, on the other hand, are not referable to any of Dr. Hunt's classes, containing as they do large proportions of sodium chloride and sodium sulphate, with smaller amounts of calcium or magnesium carbonate; the latter water which is much less saline than the former containing in addition a notable quantity of sodium carbonate. In the case of the Viau well, however, as mentioned below, it is known that water enters the bore hole at two distinct levels, the two waters differing in character.

Among the waters of the first four classes, Dr. Hunt considers the chlorides of the alkalies and alkaline earths (calcium and magnesium) which they contain, to have their origin in the limestones of the underlying palæozoic strata, from the Potsdam or the Trenton inclusive; while the sodium and potassium carbonates he believes to be derived from the argillaceous sediments which make up the Utica and Hudson river formations, these sediments containing alkaline silicates whose slow decomposition yields to the infiltrating water the alkaline carbonates and silicates which characterize the waters of Class IV.

Source of the chlorides and alkaline carbonates.

The waters of the latter class, however, on the Island of Montreal cannot find their origin in strata of these ages for the borings all start in much lower rocks. If they derive their alkaline carbonates from shales, it must therefore be from the shaly beds interstratified with the Trenton or Chazy limestones, of the same age as those which Hunt supposes to be the source of these salts in the waters of the Caledonia and Fitzroy Springs of the Ottawa Valley.* In confirmation of this, it will be noted that the several wells above mentioned as affording the soft alkaline waters of Class IV are all comparatively shallow borings, ranging from 266 feet to 567 feet in depth.

As an evidence that the different classes of waters have their origin in different strata, Dr. Hunt further mentions that springs which are unlike in composition are often found in close proximity and apparent-

Waters of different classes arising from the same fissure or boring.

* Geology of Canada, p. 562.

ly rising from a common fissure or dislocation; and he mentions among others a case in the Seigniories of Nicolet and La Baie du Febvre, where six springs rise through the Utica shale along a line in a distance of about eight miles. Of these, two belong to Class II, two to Class III and two to Class IV. These last Dr. Hunt considers to be probably derived from the shales, while the others have their source in the underlying limestones and are more or less modified in their ascent.* A somewhat similar diversity of origin must be ascribed to the waters of the Montreal district, where an equally wide range in composition is presented in an area which is much more limited in extent. As has been mentioned, the highly saline waters here usually come from the deeper wells, and an excellent case in point is afforded by the boring put down by Messrs. Viau & Frère, at Maisonneuve, in which "good water" was struck at 450 feet which rose to within 10 or 12 feet of the surface, but the boring being continued to greater depths in the hope of obtaining gas, highly saline and sulphurous water was met with at 1,497 feet, which, mingling with that first encountered, rose to the surface and overflowed at the rate of 5,000 gallons per day.

Additional information may be looked for in the future.

Much additional information regarding these waters, bearing upon the question of their composition in relation to the depths from which they rise, will undoubtedly be accumulated as time goes on, additional wells are bored and a greater number of the waters are analyzed.

Another point on which additional information may be looked for is the question as to whether any change will be observed in the character of the water yielded by a single well as it continues to be pumped for a series of years. The only well in the district from which any information has been obtained on this point, up to the present time, is that put down by Messrs. Robert White & Co., at the Laurentian Baths. Four analyses of this water, taken at intervals during a period extending over twelve years, have been given on page 47. A consideration of these will show that, while the total amount of dissolved matter has varied considerably in different years, the relative proportions of the several salts held in solution by the water has not on the whole altered much. There is, however, on the whole, a slight falling off in the amount of sodium carbonate and a slight increase in sodium sulphate present, as the years have passed.

*Chemical and Geological Essays, p. 157.

GENERAL CONCLUSIONS.

From the examination of the available data in connection with the many wells which have been sunk on the Island of Montreal, it seems certain that there is no distinct water-bearing horizon in the form of interstratified permeable beds. The water passes through the limestone series in large amount, following underground channels which have the form of irregular fissures. These fissures no doubt result from the enlargement of joint and bedding planes or of irregular cracks in the limestone by the solvent power of the waters passing through them. These enlarged fissures evidently form an irregular and complex system of water channels passing through the limestones, and occur at all depths below the surface hitherto reached by boring. The fact that the waters follow the courses of irregular fissures and not of well-defined porous beds is conclusively demonstrated by the very different results obtained by borings put down in the immediate vicinity of one another. As, for instance, on the property of Messrs. William Dow & Co., the C.P.R. workshops at Hochelaga, the Excelsior Woollen Mills, and elsewhere; wells affording an abundant supply of water being situated in the immediate vicinity of equally deep borings which supply little or no water. The Laurie Engine Company, having bored a hole to the depth of 700 feet without striking water, in another boring a few feet away obtained water at a depth of 300 feet. The character of the water also obtained from wells in the immediate vicinity of one another differs greatly, as well as the height to which the waters rise within the boring. A striking instance of this is afforded by the three wells at St. Laurent which were put down by the College, the Convent and Mr. Cousineau. In these, the water was struck at depths of 487, 250 and 128 feet, respectively. The water in the first stands at 13 feet and is soft and slightly sulphurous, that in the second rises to the surface and is very hard, while in the third well the water rises 13 feet above the surface and is of moderate hardness.

General conclusions.

Water carried in fissures.

In some cases the fissures can be distinctly recognized in boring the well, the drill dropping into an open space, this open space being in some instances empty but in other cases carrying an abundant supply of water. In the case, for example, of one well put down by the Gould Cold Storage Co., as has been mentioned, the boring tool became so firmly jammed in a transverse fissure that the hole had to be abandoned.

Fissures in some cases recognized in boring.

In the wells put down by Mr. J. N. Drummond of Petite Côte and by the Montreal Milling Co., at Outremont, "breccia" and "honey-

comb," respectively, were stated to form the water-bearing rock. These probably represent impure beds or fissures imperfectly cleared out, the more soluble material having been abstracted. In the case of the Laurentian Baths well on Craig street and Dr. Craik's well at Petite Côte, the water rises from shaly layers which probably represent the insoluble residue of a bed of argillaceous limestone, into which the water moving throught the fissures had here found its way.

Many details of evidence in support of the fact that the movement of the waters is through fissures will be met with in the descriptions of the various wells, already given. The accompanying graphic diagrams of the wells will show the great variations in depth at which water was struck in the wells in question, the height to which water rises in them, and in the thickness of the drift; all these having been plotted with reference to sea level.

Course of underground waters influenced by dykes

The course of the underground waters is also without doubt in many places rendered still more irregular by the dykes and sheets of impervious igneous rock which cut through the stratified rocks in all directions.

The amount of water now pumped daily from the wells is very large and most of them are not by any means pumped to their full capacity. In fact, the capacity of many of them has never been determined, since, when found to yield sufficient for the purposes required, no determination of the maximum yield was ever attempted.

Yield of the wells on the Island of Montreal.

An inspection of the Tabular Statement of the wells, accompanying this report, will show that at a very moderate estimate the wells already bored would yield 2,500,000 gallons per diem; which is almost exactly one tenth of the daily average amount of water pumped by the Montreal Water Works for the use of the city.

The waters obtained differ greatly in character. Very many of them are soft waters of excellent quality. Others again are hard, while a few are sulphurous or highly saline. As has been shown it is impossible to predict what the character of the water obtained at any point will be, if any be obtained, for waters of very diverse characters are pumped from wells situated in the immediate vicinity of each other or indeed may be obtained from the same well as in the case of number 78. The question of the probability of obtaining water and its character, if obtained, is however discussed on page 72.

Source of the waters.

The source of the underground waters is in all probability the higher portion of the plains along the flank of the Laurentian country in the northwestern part of the geological map-sheet. It is scarcely likely

that very much of it is derived from the Laurentian country itself, although there is reason to believe that some of it may be. Most of it probably passed underground into the palæozoic strata along the flank of the Laurentian plateau. Here the rain water would sink into the soil which almost everywhere mantles the underlying rocks, and, passing down to the surface of these rocks, would flow along it until cracks or fissures were met with, down which it would pass. An abundant supply of water is actually obtained in many places in this district by driving pipes down into the lower portions of the drift which here constitutes the soil, and thus tapping the supplies of water passing over the surface of the underlying rock. The palæozoic plain along the foot of the Laurentian plateau may be taken as having an average elevation of about 300 feet above sea level, while the surface of the Island of Montreal is much lower. The underground waters thus move to the south under considerable head or pressure, and when the channels through which they pass are tapped by borings in the vicinity of Montreal the water rises by virtue of this pressure, in a very few cases actually reaching the surface, but in the other cases remaining at different distances below it. In only five wells on the Island does the water rise more than 200 feet above sea level; the wells in question being the Park well, the wells of Messrs. Nantel and Goyer at Côte des Neiges (where the water rises 340 feet above sea level), and the wells of Messrs. Drummond and Stewart at Petite Côte, where the water rises 225 feet above sea level. In only eleven of the wells does the water rise to the surface and in only six does it overflow. These latter are the wells at the Turkish Baths, Laurentian Baths, Montreal Cold Storage Co., M. Cousineau, Messrs. Viau Frère and Messrs. Charles Gurd & Co. It will be noticed that the five wells above mentioned, in which the water rises above the 200 feet level, are all situated on the slopes of Mount Royal, and it is doubtful in how far the drainage from the mountain itself affects them.

The water rises to the surface in only eleven of the wells.

It is just possible that the Potsdam sandstone which outcrops immediately along the edge of the Laurentian plateau carries water which subsequently rises through fissures in the limestone, and it would be very interesting if a boring sufficiently deep to tap the Potsdam sandstone were made on the Island of Montreal, in order that it might be ascertained whether this formation carries any considerable supply of water. A study of the records of the borings, however, would indicate that the water-bearing channels lie chiefly in the Trenton and Chazy limestones; the deeper wells affording but little water, or water which is very impure.

Origin of hardness in waters.

Upon its source, the kind of rock traversed and its solvent power, the presence of dissolved carbonic acid, etc., depends the character of the water in any particular well. It can be readily understood that water passing through the Potsdam sandstone or the underlying Laurentian rocks and rising in fissures through the overlying strata to the surface would probably be soft. If, on the other hand, the water has traversed the limestone or dolomite throughout its entire course, following tortuous channels, a considerable amount of lime salts might be taken into solution and the water might thus become hard or possibly impure from the presence of saline and sulphurous compounds.

Chances of obtaining water by boring.

In conclusion, it may be asked as a practical question, what the chances are of obtaining water by boring in the Island of Montreal. As has been shown it is never possible to predict with certainty that water can be secured by boring at any particular spot, but a simple calculation based on the actual results obtained by the wells (89 in number) which have up to the present time (January 1, 1904) been put down in this area, shows that the chances of obtaining a large supply of water—that is to say, more than 5,000 gallons per diem—are about 7 to 2. That is to say, water will be obtained in seven out of every nine wells that are bored; while water of potable quality and in large amount will be secured in rather more than six out of every ten trials or in about two out of every three holes. In some of these however the water will be hard.

Depth to which the boring should be carried.

A second practical conclusion which can be drawn from the results which have been presented in this Report, is that if a boring is put down and water is not obtained by the time a depth of 750 feet has been reached, it is better to abandon the hole and sink another, rather than to continue boring deeper, even if this second hole has to be put down in the immediate vicinity of the first, since it has been shown that at depths greater than this abundant supplies of good water are rarely obtained, the water (if any be found) being in the great majority of cases small in amount or too impure to be of any value.

As has been stated in the sketch of the geology of the district, the maximum thickness of the several formations of the Lower Silurian, as determined from their field relations by Sir William Logan and others, is as follows in descending order:—

Lorraine	2000 feet.
Utica	300 "
Trenton Group	600 "
Chazy	300 "
Calciferous	450 "
Potsdam	700 "
Total	4350 "

Omitting the first two, the supposed maximum thickness of the last four would be 2,050 feet. Thickness of the formations.

These determinations have not been substantiated by the complete log of the Turkish Bath well or by a study of the materials obtained from the dry well bored on the property of the Montreal Gas Co., at Hochelaga. In the case of the first mentioned well, from the fossils in the rock chips, determined by Dr. Ami, and from certain accessory chemical tests, the approximate thickness of two formations was obtained. The section in descending series gave the following :—

Pleistocene (drift)	50 feet.
Trenton Group	590 "
Chazy	785 "
Calciferous	125 "
Total	1550 "

The bottom of the Calciferous was not reached, and it is possible that some of the upper beds of the Trenton have been removed by erosion, and that the Chazy alone is represented in its entire thickness.

At the Gas Company's well, an examination of the borings obtained between the 2,200 and 2,373 feet levels showed that they were derived from the Calciferous sand-rock ; and at 2,550 feet—the bottom of the well—the Potsdam sandstone had not yet been encountered. Correlating this result with the above, and allowing 600 feet and 785 feet for the maximum thickness of the Trenton and Chazy respectively, the Calciferous would have a thickness of over 1,000 feet. This discrepancy between the determination of the thickness of the several formations as they outcrop at the surface and the results obtained from the borings can be accounted for in two ways. In the first place, Faults. faults may exist which have obscured the relation of the rocks in the field. These might easily occur and escape observation, as the strata

are almost flat and so continuously covered by the drift that the rock crops out in comparatively few places.

Formations apparently thicker on going south from Laurentian margin.

Mr. LeRoy, who has made the geological map and section which accompany this Report, has in the latter shown a fault in the line of the intrusion of Mount Royal, and it seems probable from the thickness of the Utica shale in the harbour at Montreal that a fault occurs along the east side of the Island, between the Trenton and Utica formations. This belief is strengthened by the results of a boring at Laprairie, where 1,000 feet of shale were traversed and no limestone encountered.

But it would seem in the second place that there must be, in addition to any faulting, a very considerable thickening of the several formations of the Lower Silurian as the distance from the old Archæan shore line increases.

While therefore the explanation of the phenomenon is as yet uncertain the fact remains that the limestone-dolomite series has a much greater thickness than might be expected. It is hoped that the logs of future wells may throw additional light on this very interesting anomaly.

Geological Survey of Canada

ROBERT BELL, D.Sc.(Cantab.), M.D., LL.D., F.R.S., I.S.O., ACTING DIRECTOR

Explanation of Colours

Devonian

- Breccia

Cambro Silurian

- Dab — Hudson River (Lorraine)
- Daa — Utica
- Dab — Trenton group
- D2 — Chazy
- Dib — Calciferous
- Dia — Potsdam sandstone

Laurentian

- Crystalline limestone
- A — Gneiss and granite

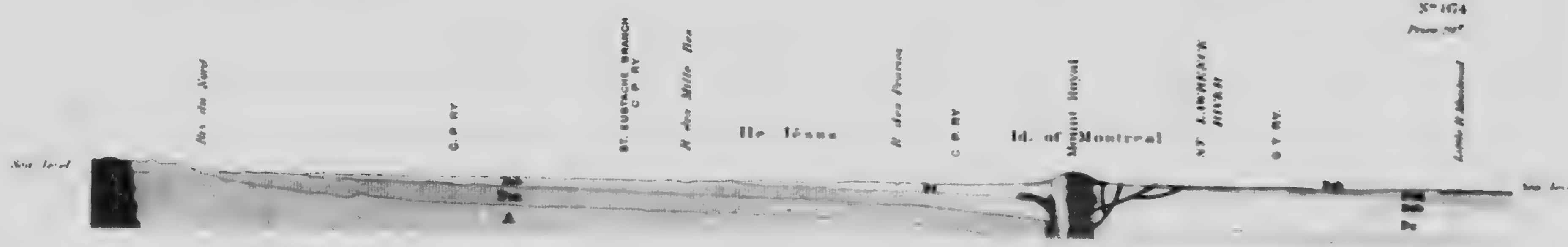
Eruptives

- Dykes and sills
- Nepheline syenite

C.O.Senécal, B.A.Sc. Geographer & Chief Draughtsman

To accompany Part R. Annual Report Vol. XIV.

N° 1674



Horizontal scale 4 miles to 1 inch.

Section along line AB.

Vertical scale 1 mile to 1 inch

GEOLOGICAL MAP
of the
ISLAND of MONTREAL and VICINITY,
PROVINCE of QUEBEC.

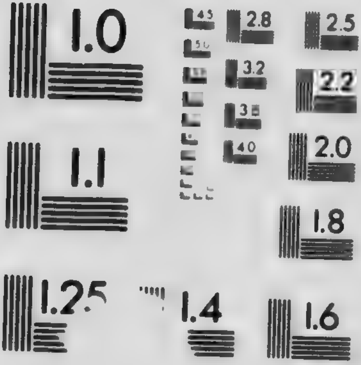
To illustrate Report on
THE ARTESIAN WELLS OF THE ISLAND,
by

FRANK D. ADAMS, D.Sc., F.G.S., F.R.S.C.
and
OSMOND E. LEROY, M.Sc.

Scale, 4 statute miles to 1 inch

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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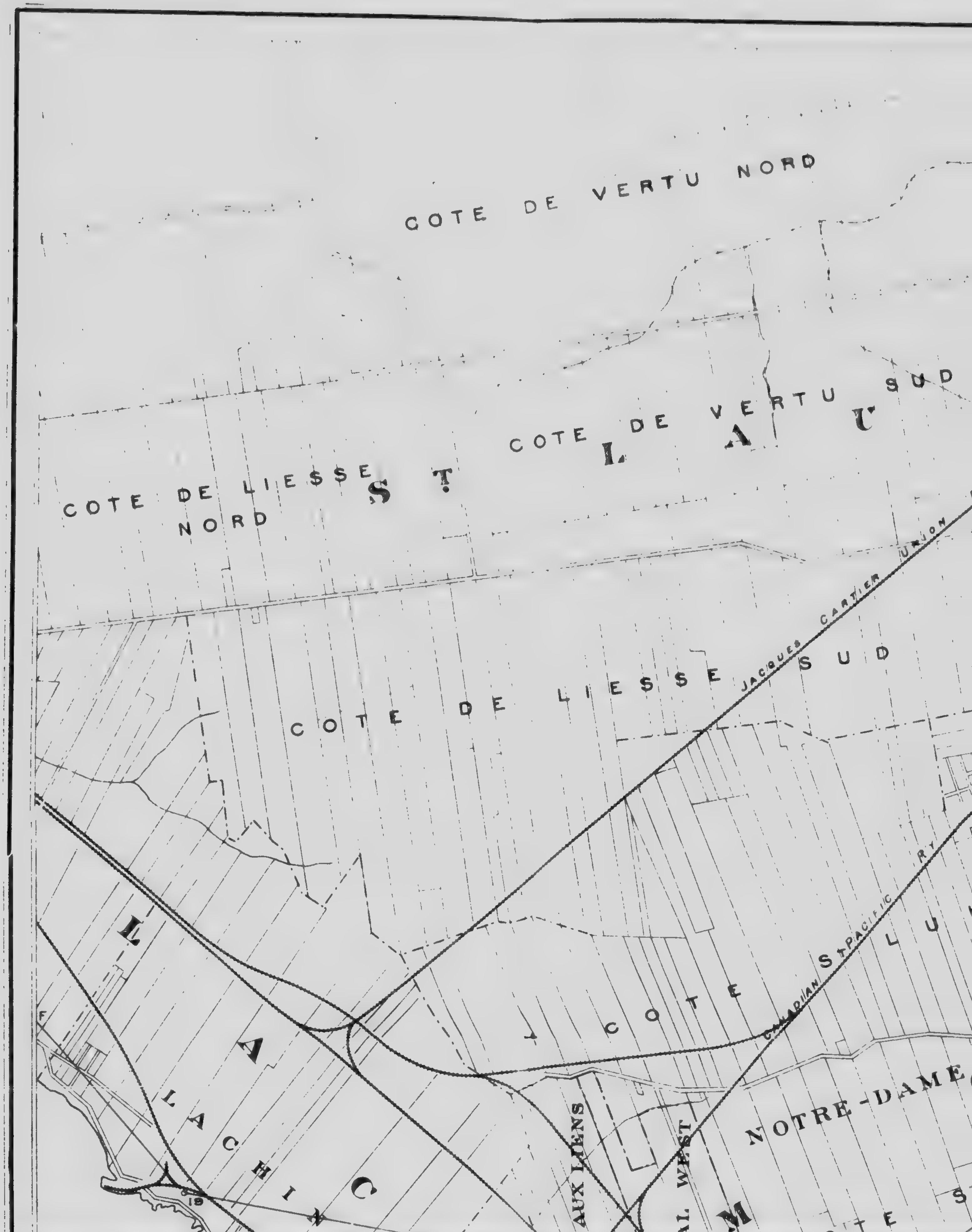
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Geological Survey of Canada

ROBERT BELL ... ACTING DIRECTOR

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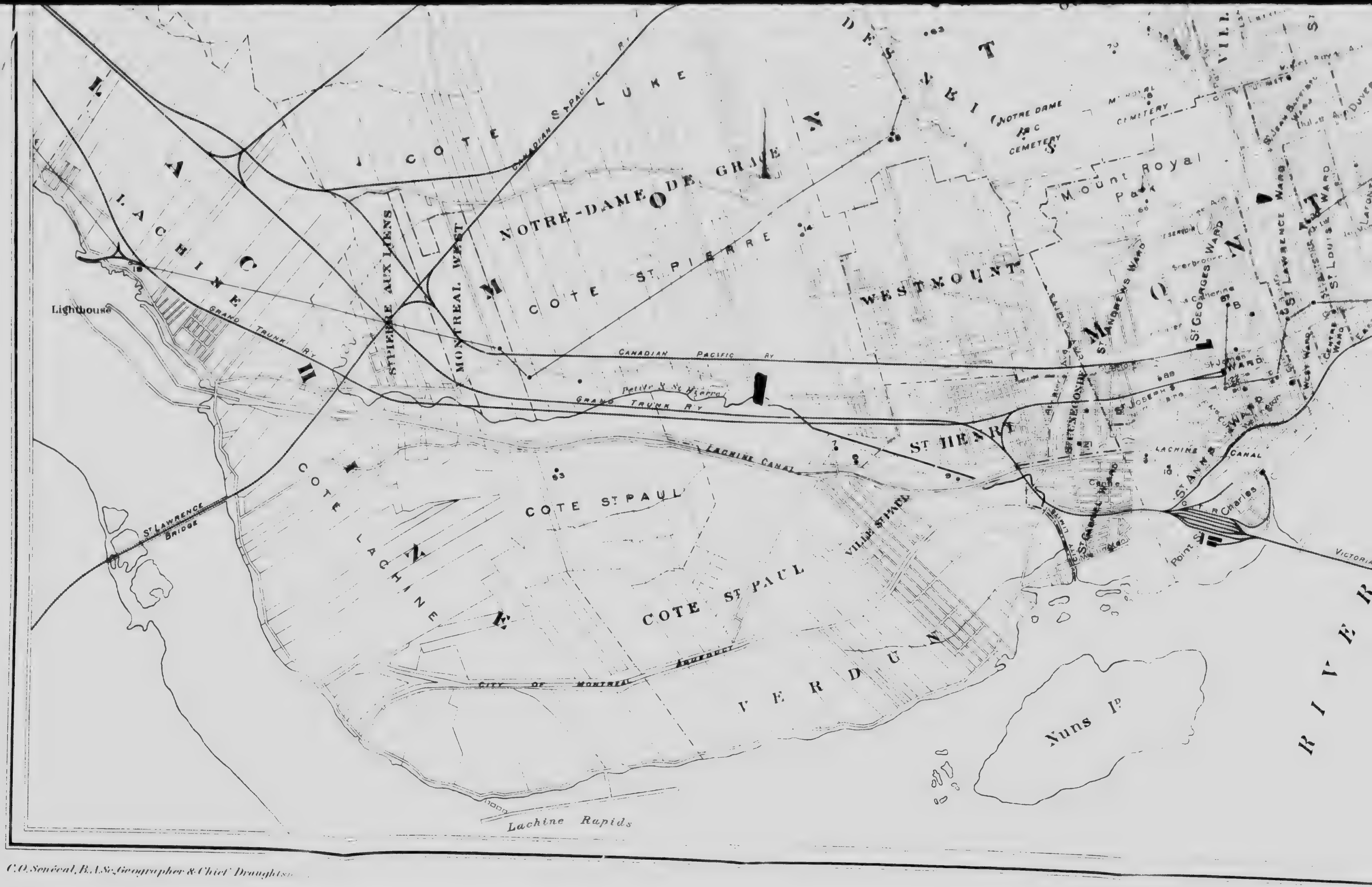
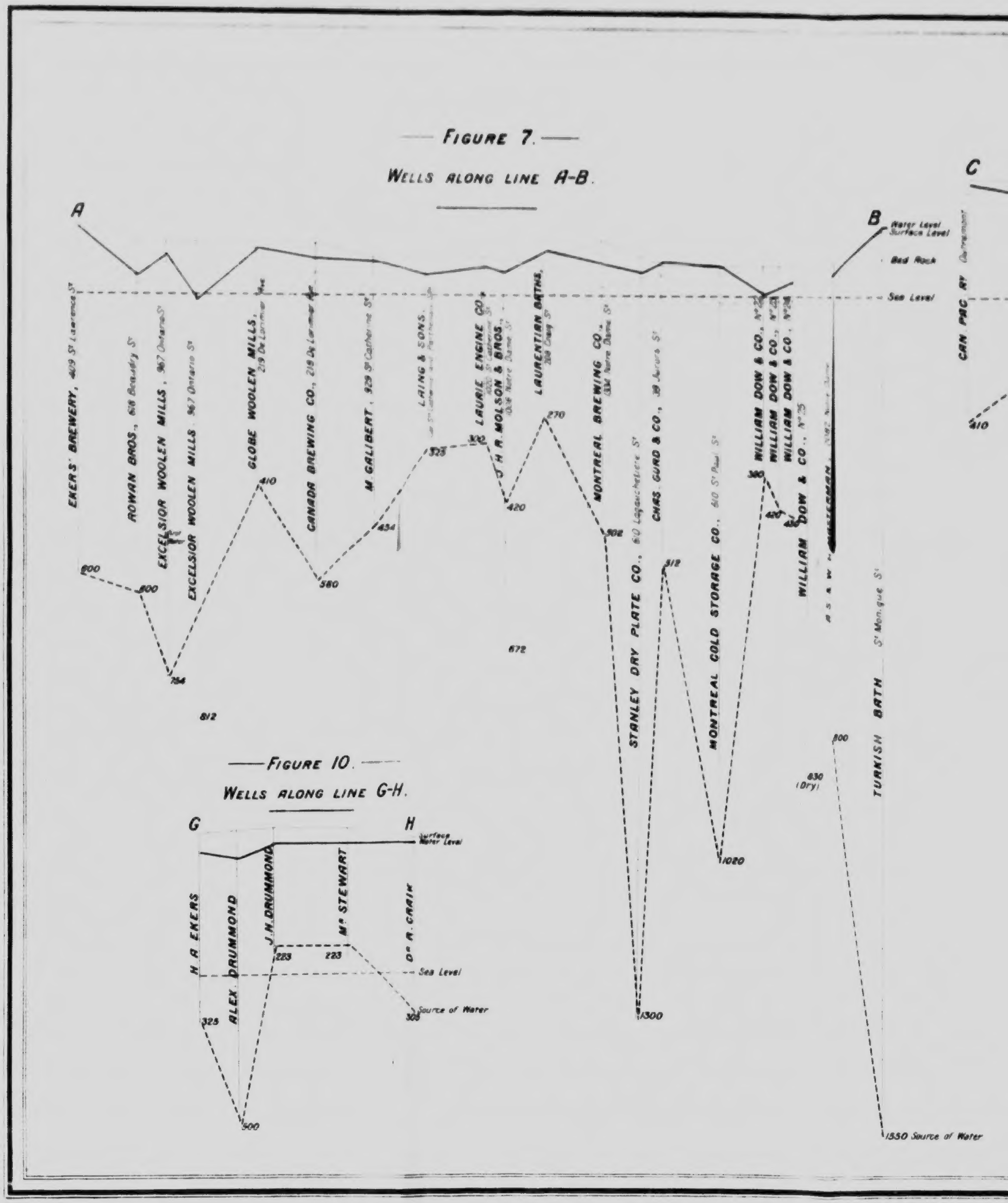


C.O. Senécal, B.A.Sc. Geographer & Chief Draughtsm

To accompany Part O, Annual Report Vol. XIV.

No. 875



GRAPHIC DIAGRAMS showing th

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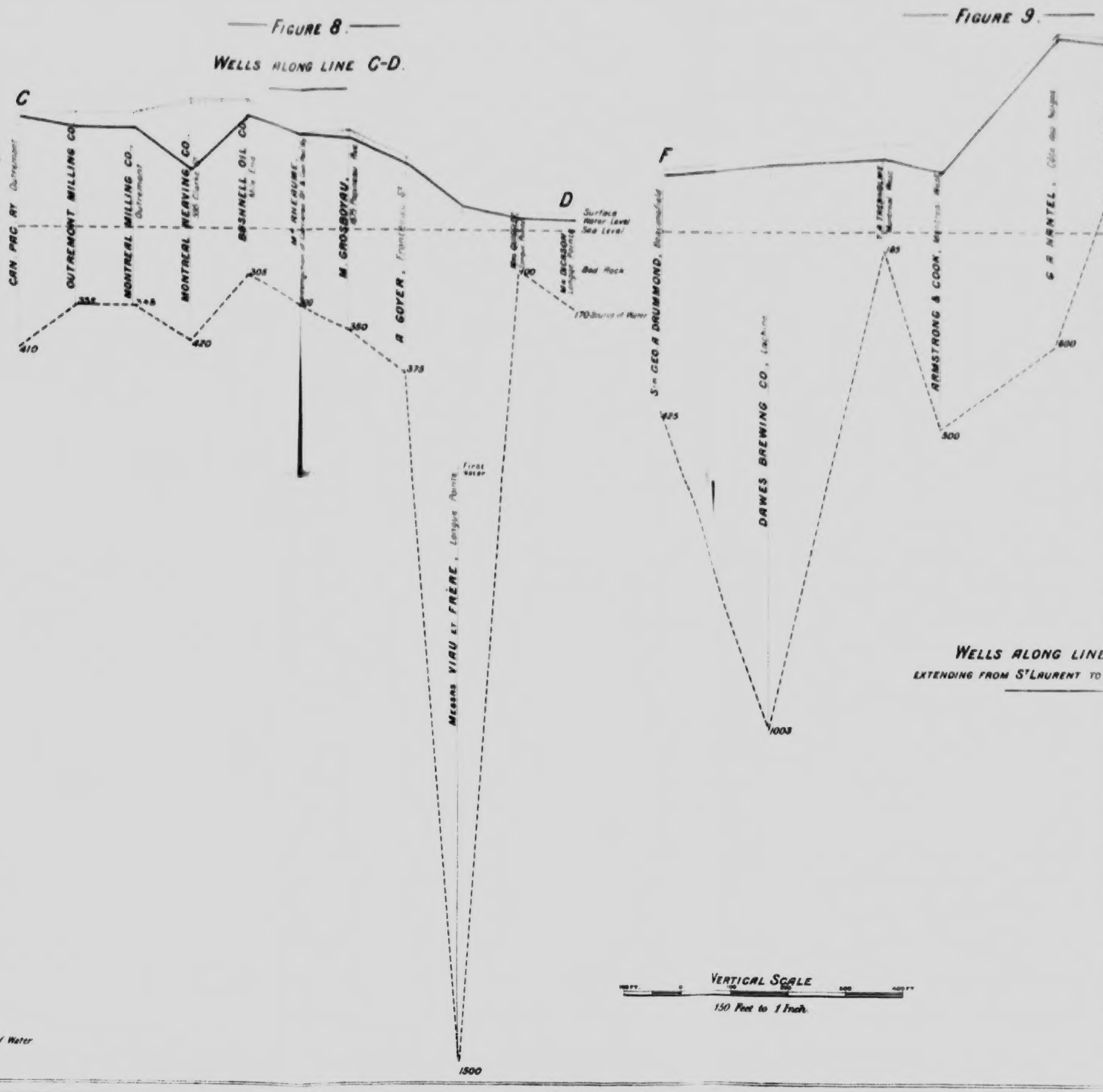
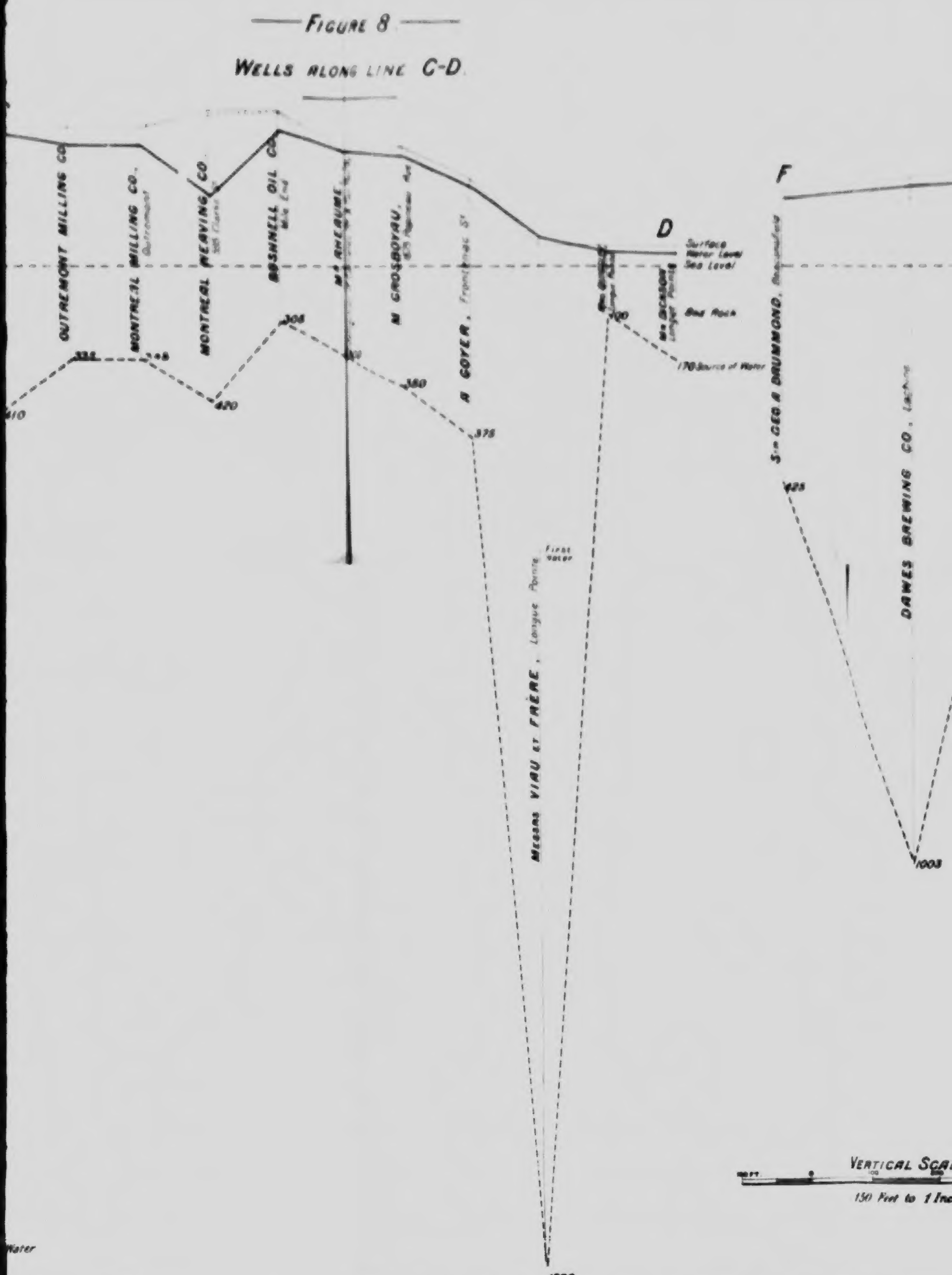


...wing the **RELATIONS** of certain groups of **WELLS** in the **CITY** of **MONTREAL** and **VICINITY**.

(See accompanying map of the City of Montreal No. 875)

Geological Survey of Canada

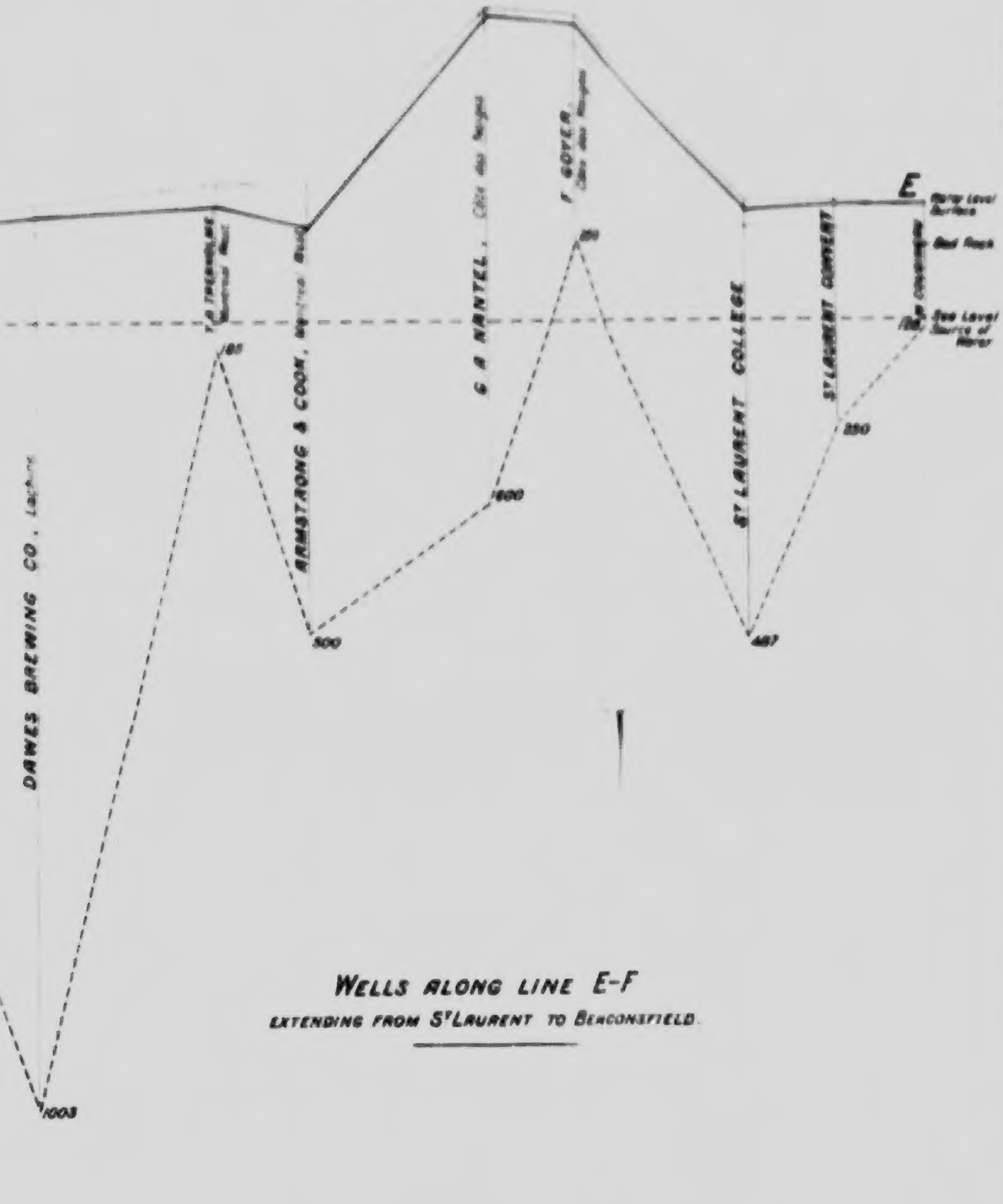
ROBERT BELL ... DIRECTOR



...ving the RELATIONS of certain groups of WELLS in the CITY of MONTREAL and VICINITY.

(See accompanying map of the City of Montreal No 875)

Figure 9.



WELLS ALONG LINE E-F
EXTENDING FROM St LAURENT TO BEACONSFIELD.